Trace nutrients. 3* Magnesium, copper, zinc, vitamin B_6, vitamin B_{12} and folic acid in the British household food supply

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1. Intakes of magnesium, copper, zinc, vitamin B_6, vitamin B_{12} and folic acid in Britain were calculated by applying the values selected for the 4th edition of *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978) to the amounts of food recorded in the National Food Survey made during 1976 (Ministry of Agriculture, Fisheries and Food, 1977).

2. National average intakes were (/person per d): Mg 249 mg, Cu 1·51 mg, Zn 9·1 mg, vitamin B_6 1·36 mg, vitamin B_{12} 6·6 μg, free folic acid 105 μg and total folic acid 190 μg. Corresponding intakes (/person) in families with four or more children were 10–20 % lower.

3. A comparison of intakes with those recommended in Canada (Department of National Health and Welfare, 1976) and the USA (National Research Council, 1974) or by WHO (1973) indicated that for folic acid average values were particularly low, and only for vitamin B_{12} were the recommendations significantly exceeded.

4. Contributions from alcoholic drinks and confectionery were also calculated and found, on average, to be significant for Cu, vitamin B_{12} and folic acid.

5. The losses of B-vitamins which might occur on cooking are discussed.

In Britain, two minerals (iron and calcium) and six vitamins (thiamin, riboflavin, nicotinic acid, vitamin A, vitamin C and vitamin D) have been evaluated in numerous dietary studies. Other minerals and vitamins have rarely been considered and there appear to be two main reasons for this. The first is that the standard tables of food composition in this country (McCance & Widdowson, 1960) and in America (Watt & Merrill, 1963) have long contained more extensive information on these than on other vitamins and minerals with the exception of magnesium and the major electrolytes. The second is that the nutritional adequacy of diets is most readily assessed by comparing intakes against recommended intakes of nutrients and, in Britain, detailed recommendations have been limited to the eight minerals and vitamins mentioned previously together with protein and energy (British Medical Association, 1950; Department of Health and Social Security, 1969).

The National Food Survey is no exception, and it has monitored the amounts of these nutrients together with the proximate constituents continuously since the Second World War (Ministry of Food, 1951). Recently, however, the Ministry of Agriculture, Fisheries and Food has been widening its knowledge of minor nutrients and other trace constituents in the nation's food supply, and the completion of the extensive revision of *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978) has already enabled details of the essential amino acids (Buss & Ruck, 1977) and cholesterol (Spring *et al.* 1978) in the British household food supply to be calculated. The present paper extends this work to a further three minerals and three vitamins.

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METHODS

The method of calculating the amounts of minor nutrients in the household food supply was essentially that which is routinely used for the major minerals and vitamins in the Annual Reports of the National Food Survey Committee (see Ministry of Agriculture, Fisheries and Food, 1974, Appendix A).

The present study relates to 1976. In that year, 7521 randomly selected British households containing 21 987 people participated in the National Food Survey. Each housewife recorded in as much detail as possible the type and quantity (and cost) of each food she bought or obtained free during the course of the week in which she (or he) participated, as well as the age and sex of the people present at each meal so that recommended intakes of nutrients could subsequently be calculated. Meals and snacks eaten outside the home were not recorded unless they were made from the household food supply, e.g. a picnic. Neither were alcoholic drinks or sweets included, for the housewife would be unlikely to know with any accuracy the amounts obtained by members of her family. Each food was then assigned to one of 153 different groups of foods. The amounts obtained by households in each of the main regions of Britain, and by households with different incomes and family compositions, as well as national averages, were then calculated and have already been published (Ministry of Agriculture, Fisheries and Food, 1977).

We applied to these quantities the analytical and literature values for magnesium, copper, zinc, vitamin B_6, vitamin B_{12}, free folic acid and total folic acid which were selected for inclusion in the 4th edition of *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978). Allowance was made for the proportion of each food which is not edible, but not for any subsequent wastage of edible material nor for any further losses of nutrients which might occur during cooking.

The significance of the results was assessed by comparing the nutrient content of this food supply in all households and in families with four or more children (177 households, 1122 people) with recommended intakes of nutrients. As no detailed recommendations have been made in this country for any of the nutrients in this study (Department of Health and Social Security, 1969), comparisons were made with the intakes recommended in the USA or in Canada (National Research Council, 1974; Department of National Health and Welfare, 1976) or by the WHO (1973), after deduction of 10 % as a standard allowance for wastage as in the National Food Survey (Ministry of Agriculture, Fisheries and Food, 1977).

As beer contains significant amounts of vitamin B_{12} and folic acid and cocoa is rich in Cu, the potential contributions of alcoholic drinks and confectionery to average intakes of the nutrients in this study were also estimated. Consumption had to be taken as the total amounts available per person in the United Kingdom because the National Food Survey includes no relevant records; that of beer, wines and spirits was derived from H.M. Customs and Excise Department (1977) and that of chocolate and sugar confectionery from the Cocoa, Chocolate and Confectionery Alliance (1977), and each was then divided by the total population of the United Kingdom. Their nutrient contents were again taken from Paul & Southgate (1978).

RESULTS

The amounts of Mg, Cu, Zn, vitamin B_6, vitamin B_{12} and free and total folic acid in the household diet, and the contributions made to the totals by major groups of the 153 types of food evaluated, are summarized in Table 1.

In every instance the total amount per person was higher in the average household food supply than in families with four or more children. This finding does not of itself indicate

Table 1. *Contributions (/person per d) made by groups of foods to selected minor nutrients in British household food in* 1976

	Magnesium (mg)	Copper (mg)	Zinc (mg)	Vitamin B_6 (mg)	Vitamin B_{12} (μg)	Free folic acid (μg)	Total folic acid (μg)
			(*a*) National average				
Liquid milk	47	0·08	1·4	0·15	1·2	15	20
Cheese	4	0·01	0·6	0·01	0·2	—	3
Beef, lamb and pork	9	0·08	1·7	0·14	0·9	1	3
Liver and other offals	1	0·19	0·2	0·02	2·5	5	7
Other meat and meat products	12	0·16	1·4	0·15	0·5	2	3
Fish	4	0·02	0·1	0·06	0·6	1	2
Eggs	4	0·03	0·4	0·03	0·5	7	7
Potatoes	26	0·17	0·3	0·27	—	11	16
Other fresh and processed vegetables	27	0·17	0·6	0·20	—	31	54
Fruit and fruit products	12	0·07	0·1	0·08	—	7	11
Bread	43	0·21	1·2	0·06	—	10	38
Flour, cakes and biscuits	16	0·09	0·4	0·06	0·1	6	10
Other cereals and cereal products	15	0·06	0·4	0·05	—	2	6
All other foods	28	0·17	0·3	0·07	0·1	6	11
Totals	249	1·51	9·1	1·36	6·6	105	190
			(*b*) Families with four or more children				
Liquid milk	46	0·08	1·3	0·15	1·2	15	19
Cheese	3	0·01	0·4	0·01	0·1	—	2
Beef, lamb and pork	7	0·06	1·2	0·10	0·6	1	2
Liver and other offals	1	0·16	0·1	0·02	2·1	4	6
Other meat and meat products	10	0·13	1·1	0·11	0·5	2	3
Fish	2	0·01	0·1	0·03	0·3	1	1
Eggs	3	0·03	0·4	0·03	0·4	6	6
Potatoes	25	0·16	0·3	0·26	—	10	15
Other fresh and processed vegetables	22	0·14	0·5	0·16	—	21	39
Fruit and fruit products	10	0·05	0·1	0·06	—	5	8
Bread	41	0·21	1·2	0·06	—	10	38
Flour, cakes and biscuits	17	0·09	0·4	0·07	(0·03)	7	11
Other cereals and cereal products	19	0·08	0·4	0·06	—	3	7
All other foods	20	0·16	0·2	0·07	0·1	4	8
Totals	226	1·36	7·9	1·19	5·3	88	165

that larger families are less well nourished, since children have smaller absolute needs for most nutrients than do adults. Indeed, the apparent adequacy of the Mg intake in larger families exceeded that of the national average household (Table 2), while the adequacy of the other nutrient intakes was in general only 0–10 % less in the larger families compared with 10–20 % deficits in intakes expressed per person.

The additional contributions made by alcoholic drinks and confectionery to Mg, Cu, Zn, vitamin B_6, vitamin B_{12} and folic acid intakes are summarized in Table 3.

DISCUSSION

In most households, the foods bought during the course of any one week are not exactly the same as those eaten during that period. Nevertheless, in the present survey, it was not considered unreasonable to equate food purchases and food eaten in the home (after allowing

Table 2. *Adequacy** (*% recommended intakes*) *of selected minor nutrients* (*less* 10 %) *in the British household food supply*

	National average	Families with four or more children
Magnesium†	100	105
Copper‡	88	87
Zinc†	99	90
Vitamin B_6†	80	74
Vitamin B_{12}†	235	204
Free folic acid†	57	56
Total folic acid§	50	47

* For procedures, see p. 488; no allowances were made for possible cooking losses.
† Recommendation based on Department of National Health and Welfare (1976).
‡ Recommendation based on WHO (1973).
§ Recommendation based on (US) National Research Council (1974).

Table 3. *Average contributions* (*/person per d*) *made by alcoholic drinks and confectionery to minor nutrients in* 1976

	Magnesium (mg)	Copper (mg)	Zinc (mg)	Vitamin B_6 (mg)	Vitamin B_{12} (μg)	Free folic acid (μg)	Total folic acid (μg)
Alcoholic drinks	28	0·19	0·1	0·07	0·5	13	20
Confectionery	11	0·11	—	—	—	2	2

for wastage) because the sample was large and the survey was conducted throughout the year. In contrast, the nutrients ingested would have been different from the nutrient content of the food bought, since (*a*) the quantities of food considered in this paper would have been supplemented not only by alcoholic drinks and sweets (Table 3) but also by meals and snacks eaten outside the home; however, although the latter would increase absolute intakes, they would have comparatively little effect on the apparent adequacy of the diet because the comparisons with recommended intakes have made allowance for meals not taken from the household food supply; and (*b*) there would have been significant losses of some of these nutrients when the foods were cooked. These are discussed in more detail for each nutrient.

Mg. The average household diet provided 249 mg/person per d which exactly met the Canadian recommended intake (Department of National Health and Welfare, 1976), while the intake of 226 mg/person in larger families slightly exceeded their recommendation for a sample of the same age and sex structure. These intakes were remarkably similar to those in a sample of 1000 households studied 35 years ago by Duckworth & Warnock (1942), who found an average intake of 230 mg/d (range 162–379 mg/d). At 26 mg/MJ, the average intake was slightly lower than that from average American and Canadian diets (29 and 31 mg/MJ respectively; National Research Council, 1974; Department of National Health and Welfare, 1976), but it would have been supplemented by 39 mg/person per d from alcoholic drinks and confectionery on average (Table 3), or much more in the instance of heavy beer drinkers.

The main food sources of Mg were cereals and cereal products (30 %, of which 17 % was derived from bread), vegetables (21 %, of which 11 % was derived from potatoes), and milk (19 %). Liquid milk made the largest contribution of any single food, although it has been said to be a relatively poor source (WHO, 1973). These values for relative contributions have changed from those found by Duckworth & Warnock (1942) of 34 % from cereals,

36 % from vegetables and 13 % from milk. A small amount of Mg could be lost from vegetables on cooking (Dauncey & Widdowson, 1972).

Cu. The household diet provided 1·51 mg/person per d on average and 1·36 mg/person per d in large families. The WHO (1973) recommendations are related to body-weight; taking the recommended Cu intakes conservatively as 80 μg/kg for infants and young children up to the age of 9 years, 40 μg/kg for older children from 9 to 17 years and 30 μg/kg for all adults, and British body-weights as given by the Department of Health and Social Security (1969), these intakes would appear to satisfy only 88 and 87 % respectively of the weighted average recommendation. Nevertheless, these intakes are higher than those obtained in recent studies of selected American diets (Klevay, 1977) and would be supplemented by 0·3 mg/person per d from alcoholic drinks and chocolate confectionery and by the Cu in some water supplies (Commins, 1978). These intakes are also similar to estimates obtained from UK total diet studies (Ministry of Agriculture, Fisheries and Food, 1978), and, at 0·16 mg/MJ, to the intakes of 0·17 mg/MJ recorded in Canada (Department of National Health and Welfare, 1976). But they are substantially lower than previous values such as that of 2·9–3·4 mg/man value per d recorded in Scotland from 1926–1933 (Davidson *et al.* 1933) and the intakes of 2–2·5 mg/d quoted by the Department of Health and Social Security (1969) when concluding from the absence of any reports of deficiency that United Kingdom diets must contain adequate Cu.

Although green vegetables, fish, oysters, cocoa and liver are particularly rich in Cu, their consumption in Britain is low and the main sources were meat and meat products (28 %, with liver and other offals contributing 12 %), cereals and cereal products (24 %, of which 14 % was derived from bread), and vegetables (21 %, with 11 % provided by potatoes).

Zn. The average Zn content of the household diet was 9·1 mg/person per d and the value for larger families was 7·9 mg/person per d. These values were less than that of 11·16 mg estimated by Davies (1977) from food consumption patterns indicated by the National Food Survey of 1974 (Ministry of Agriculture, Fisheries and Food, 1977) and American values for the Zn content of foods. They were also less than the value of 11 mg estimated by the differing approach of the total diet study made in 1974 (Ministry of Agriculture, Fisheries and Food, 1978), and than earlier estimates of 10–15 mg/d (Department of Health and Social Security, 1969; (US) National Research Council, 1974). At 0·95 mg/MJ, they were also less than Canadian intakes of 1·1–1·4 mg/MJ (Department of National Health and Welfare, 1976). Dietary requirements depend very much upon the proportion of the Zn which is absorbed, but the present intakes do nearly meet Canadian recommendations (Department of National Health and Welfare, 1976) although they are substantially lower than previous American recommendations (National Research Council, 1974).

The major dietary source was meat and meat products (36 %, of which half came from beef, lamb and pork), so vegetarians may be at some risk. Other significant contributions were made by milk and cheese (22 %, with milk alone providing 15 %) and cereals and cereal products (22 %, of which 13 % was from bread). In larger families, the contributions from meats, milk and cheese, and cereals were 30, 22 and 25 % respectively.

Vitamin B_6. The average intake of 1·36 mg/person per d was less than the value of 1·6–1·9 mg calculated for the total food supplies in the 1950s (Hollingsworth *et al.* 1956) but within the range of 1–2 mg/d said to be enough for most people in this country (Department of Health and Social Security, 1969). It met only 80 % of the more detailed American (National Research Council, 1974) or Canadian (Department of National Health and Welfare, 1976) recommendations, however, and the intake in larger families met only 74 % of these recommendations. But pyridoxine requirements are related to protein intakes, and if the Canadian (Department of National Health and Welfare, 1976) recommendation of 0·02 mg/g protein is generally applicable, pyridoxine intakes both in the average household

and in larger families would, at 0·019 mg/g protein, have met approximately 95 % of the population's needs (the protein content of these diets is given by the Ministry of Agriculture, Fisheries and Food, 1977). On the other hand, pyridoxine is water-soluble and heat-labile. The differences between the pyridoxine contents of raw and the equivalent cooked foods are summarized in *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978); losses during the cooking of meat and vegetables may range from 25 to 50 % and there will also be significant losses when fish, eggs, and some cereal products are cooked. It is therefore of interest that some English women, particularly if taking oral contraceptives, have shown biochemical signs of pyridoxine deficiency and respond to large (20 mg/d) doses of the vitamin (Adams, Wynn *et al.* 1973).

The main sources of vitamin B_6 in the diet as purchased were vegetables (35 %, with 20 % coming from potatoes) and meat (23 %, with bacon and ham providing 14 %). As animal products including milk and eggs provided 42 % of the intake, strict vegans may be at some risk although an increased consumption of wholemeal bread (which contains nearly four times as much vitamin B_6 as white bread) could compensate. The amount derived from potatoes would also be higher in most years: 1976 was extremely hot and dry and potatoes were in short supply.

Vitamin B_{12}. Intakes were 6·6 μg/person per d on average, and 5·3 μg in larger families where animal products tend to form a smaller part of the diet. In both instances, recommended intakes were substantially exceeded. The main contributors were offals (38 %), other meat and meat products (22 %) and milk (18 %) while in families with four or more children the corresponding proportions were very similar (38, 21 and 22 %, respectively). This study cannot indicate how low the intakes of vegetarians can be, and it should also be noted that vitamin B_{12} can be lost during cooking. In particular, *McCance and Widdowson's The Composition of Foods* (Paul & Southgate, 1978) indicates that up to 20 % of the vitamin B_{12} present may be lost during the roasting of meat. Other examples of the difference between calculated values and the amounts present in cooked food have been given by Adams, McEwan *et al.* (1973).

Beer contains significant amounts of vitamin B_{12}, and could provide a further 0·5 μg/person per d (Table 3).

Folic acid. Free folic acid is believed to be completely available to man, but the longer-chain polyglutamates may be utilized only partially or not at all. Consequently, recommended intakes are sometimes set in terms of free folic acid alone (when other forms may provide a bonus) or higher recommendations are made in terms of total folic acid (Truswell, 1976). We have evaluated the British diet in terms of both free and total forms and on both bases the intakes satisfy only half the recommendations (Table 2).

All folic acid values were based on recent analyses where ascorbic acid had been added to the sample to prevent loss (Paul & Southgate, 1978). The main contributors to the calculated intakes of free folic acid were found to be vegetables (40 %, with fresh green vegetables providing 17 %, potatoes 10 %, and canned, frozen and root vegetables 13 %), cereals and cereal products (18 %, of which 10 % came from bread) and milk (15 %), while the corresponding contributions to the lower overall intake in large families (Table 1) were 36, 21 and 17 % respectively.

Cereals made a proportionately larger contribution to intakes of total folic acid: 28 % in the average household with 20 % derived from bread alone, and 34 % in large families. Beer can also be a useful source of folic acid, and the amount available in the United Kingdom could provide a further 13 μg free folate/d or 20 μg total folate (or more to regular beer drinkers), and there is evidence that tea may also contribute appreciable amounts (Stagg & Millin, 1975).

Because of the importance of vegetables in providing folic acid, it is significant that

20–50 % of the total folate and 90 % of the free folate are lost when vegetables are cooked. The following additional losses of this water-soluble, heat-labile, and alkali-sensitive vitamin are also given in Paul & Southgate (1978): offals 30 %, eggs 10–35 % for free folate, fish 0–50 % for free and 0–20 % for total folate, milk 5 %; and for those cereal products which need further cooking 50–90 % for free folate and 50 % for total folate. Together, these losses would cause a substantial reduction in the folic acid content of the household food supply by the time it is eaten.

There will be considerable variations about these means, and Dickerson (1978) reports intakes as low as 31 and 33 μg/d in elderly people. Furthermore, in a recent review, Chanarin (1975) estimated that intakes of total folate in British diets as eaten are between 129 and 300 μg/d and stated that folic acid deficiency occurs in approximately 10 % of elderly people and in approximately 30 % of women in pregnancy in this country.

REFERENCES

Adams, J. F., McEwan, F. & Wilson, A. (1973). *Br. J. Nutr.* **29**, 65.

Adams, P. W., Wynn, V., Rose, D. P., Seed, M., Folkard, J. & Strong, R. (1973). *Lancet* i, 897.

British Medical Association (1950). *Report of the Committee on Nutrition.* London: British Medical Association.

Buss, D. H. & Ruck, N. F. (1977). *J. hum. Nutr.* **31**, 165.

Chanarin, I. (1975). In *Getting the Most out of Food*, no. 10, p. 41. Burgess Hill, Sussex: Van den Berghs & Jurgens.

Cocoa, Chocolate and Confectionery Alliance (1977). *Annual Report* 1976–77. London: Cocoa, Chocolate and Confectionery Alliance.

Commins, B. T. (1978). *Brit. Nutr. Foundation Nutr. Bull.* **4**, 380.

Dauncey, M. J. & Widdowson, E. M. (1972). *Lancet* i, 711.

Davidson, L. S. P., Fullerton, H. W., Howie, J. W., Croll, J. M., Orr, J. B. & Godden, W. (1933). *Br. med. J.* i, 685.

Davies, N. T. (1977). In *Child Nutrition and Its Relation to Mental and Physical Development*, p. 21. Manchester: Kellogg Company of Great Britain.

Department of Health and Social Security (1969). *Rep. publ. Hlth med. Subj.* no. 120.

Department of National Health and Welfare (1976). *Dietary Standard for Canada.* Ottawa: Supply and Services Canada.

Dickerson, J. W. T. (1978). *Roy. Soc. Hlth J.* **2**, 81.

Duckworth, J. & Warnock, G. M. (1942). *Nutr. Abstr. Revs* **12**, 167.

H.M. Customs and Excise Department (1977). *68th Report of the Commissioners of H.M. Customs and Excise.* London: H.M. Stationery Office.

Hollingsworth, D. F., Vaughan, M. C. & Warnock, G. M. (1956). *Proc. Nutr. Soc.* **15**, xvii.

Klevay, L. M. (1977). In *Advances in Nutritional Research*, p. 227 [H. H. Draper, editor]. London: Plenum Press.

McCance, R. A. & Widdowson, E. M. (1960). *Spec. Rep. Ser. med. Res. Coun.* no. 297.

Ministry of Agriculture, Fisheries and Food (1974). *Household Food Consumption and Expenditure: 1972.* London: H.M. Stationery Office.

Ministry of Agriculture, Fisheries and Food (1977). *Household Food Consumption and Expenditure: 1976.* London: H.M. Stationery Office.

Ministry of Agriculture, Fisheries and Food (1978). *The Surveillance of Food Contamination in the United Kingdom.* London: H.M. Stationery Office.

Ministry of Food (1951). *The Urban Working-Class Household Diet 1940 to 1949.* London: H.M. Stationery Office.

National Research Council (1974). *Recommended Dietary Allowances*, 8th ed. Washington, DC: National Academy of Sciences.

Paul, A. A. & Southgate, D. A. T. (1978). *McCance and Widdowson's The Composition of Foods*, 4th ed. Ministry of Agriculture, Fisheries and Food and Medical Research Council. London: H.M. Stationery Office.

Spring, J. A., Robertson, J. & Buss. D. H. (1978). *Proc. Nutr. Soc.* **37**, 73A.

Stagg, G. V. & Millin, D. J. (1975). *J. Sci. Fd Agric.* **26**, 1439.

Truswell, A. S. (1976). *Proc. Nutr. Soc.* **35**, 1.

Watt, B. K. & Merrill, A. L. (1963). Agriculture Handbook no. 8.

WHO (1973). *Tech. Rep. Ser. Wld Hlth Org.* no. 532.

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