Br. J. Nutr. (1979) 42, 413

Zinc deficiency in the West of Scotland? A dietary intake study

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(*Received* 16 *February* 1979 – *Accepted* 13 *June* 1979)

1. The intake of zinc in the West of Scotland was determined by atomic absorption spectrometry, in ninety-six items of food which make up the local standard diet for 1 week.

2. The diet contained less Zn than the recommended daily allowance ((US) National Academy of Sciences, 1974). This finding either indicates the need for a revision of the suggested allowances or suggests that a change of diet is necessary.

3. The change could be made simply by the substitution of wholemeal flour for white flour. Other changes in diet were considered but they were unlikely to be acceptable. Even with changes the requirement of pregnant or lactating women would not be met. If the recommended allowances are valid these women must be deficient in Zn.

Zinc is an essential trace element for man. Chronic Zn deficiency occurring locally in the Middle East has been demonstrated in man by Prasad *et al.* (1963) and Prasad (1966). The optimal dietary intake of Zn is not known. The US Food and Drug administration have recommended a daily intake of 15 mg; so far there is no recommendation as to the daily intake of biologically available Zn. The nature of the diet influences the availability of Zn through the formation of non-absorbable Zn chelates (O'Dell *et al.* 1972; Reinhold *et al.* 1973; Evans & Johnstone, 1977).

Underwood (1971), Sandstead (1973) and Schroeder (1974) consider that the Zn contents of various American diets are marginal and that subclinical Zn deficiency is widespread. The purpose of this work is to measure the dietary intake of Zn in the West of Scotland.

EXPERIMENTAL

Diets vary considerably reflecting different traditions and the availability of local produce. The science department at The Queen's College, Glasgow, records current trends in eating habits. This information was used to plan a typical 1 week menu for a family of four. Each dish was prepared in the traditional manner. The quantities were sufficient for two adults and two children aged 8 (girl) and 12 (boy) years.

The daily diet for the adult male contains an average 12·5 MJ, 96 g protein, 140 g fat and 339 g carbohydrate. The fat content of the diet (considered to be higher than necessary) supplies over 40% of the energy.

The ingredients (ninety-six items of food spread over 7 d) of each meal forming the total diet were individually homogenized, after cooking, using a Colworth 'Stomacher'. The samples were then freeze-dried and approximately 1 g samples of the material were analysed

0007-1145/79/3292-1306 $01.00

Table 1. *Zinc content of the West of Scotland diet**

	Zn (mg/week)	Energy (MJ/week)	Zn:energy (μg Zn/kJ)
Meat	83	46·6	1·78
Fish (fried)	2·4	3·6	0·67
Cereals	58·2	99·9	0·58
Dairy produce	47	67·6	0·69
Vegetables	19·1	27·2	0·69
Fruit (tinned included)	2·3	8·5	0·26
Soup	10·6	12·3	0·86
Desserts	7·7	8·5	0·91
Beverages	7·3	3·2	2·27
Sugar–confectionery	2·0	22·3	0·09
Miscellaneous	3·5	3·7	0·96

* Zn contents of the individual items in the diet are available from the authors.

Table 2. *The daily zinc intake in the Glasgow area*

	Recommended daily allowance*		Determined daily intake		
	Energy (MJ)	Zn (mg)	Energy (MJ)	Zn (mg)	Zn deficiency (%)
Adult male (23+years)	11·3	15	12·6	10·1	33
Adult female (23+years)	8·4	15	9·5	7·6	49
Young male (12 years)	11·7	15	12·1	9·7	35
Young female (8 years)	10·0	10	9·1	7·3	27
Pregnant female	+1·3	20	—	—	—
Lactating female	+2·1	25	—	—	—

* National Academy of Sciences, 1974.

by the atomic absorption method described by Scott *et al.* (1971). The method involved the destruction of organic matter by dry ashing at 450° followed by extraction with 6 M hydrochloric acid. Samples of National Bureau of Standards orchard leaves, bovine liver and other reference materials were included in each batch of analyses. The Zn values obtained for these materials were in good agreement with the certificated or recommended values.

RESULTS

The weekly dietary intake of Zn for a family of four in the West of Scotland was estimated to be 243 mg (Table 1). The daily family intake ranged from 20·3 to 46·1 mg with a mean of 35 (SD $\pm$ 10). The average daily intake per person could be estimated on the basis that the diet was consumed in the following proportions: adult male 0·29, male child (12 years) 0·28, adult female 0·22, female child (8 years) 0·21. These values were taken from dietary information collected by The Queen's College, Glasgow. Using this information the daily intake of Zn could then be compared (Table 2) with the recommended daily allowance (RDA; National Academy of Sciences, 1974).

DISCUSSION

The RDA is not the daily requirement but an estimate believed to exceed the requirements of most people. Clearly, the Zn intakes reported here fall below the RDA for all the categories studied. This does not necessarily mean that the diet contains an insufficient amount of Zn. The daily requirement for Zn is not well known, but some studies (Food and Nutrition Board, 1970; White & Gynne, 1971) suggest a daily requirement ranging from 8 to

12 mg. Viewed against these values the Zn intake of the inhabitants of the West of Scotland is not quite adequate and it is possible that some individuals may be subclinically deficient.

If this suggestion of subclinical deficiency is accepted how can the Zn intake of the population be increased without increasing the energy value of the diet? The measurement that must be considered in trace-element nutritional studies is the amount of biologically available element/J. In general the biological availability is not known, so that the total amount of the element/J must be used; nevertheless, this is more useful than the concentration of the element in a particular food. Table 1 gives the Zn and energy content of the main components of the weekly diet for a family of four in the West of Scotland. If the Zn content alone is quoted for a foodstuff, then comments such as 'garden vegetables and fruits have a relatively low zinc content' (Sandstead, 1973), mislead because leafy vegetables have a high Zn content/J and are a good source of trace elements if eaten in sufficient quantity.

The adult male requires, on average, food that provides 1·24 μg Zn/kJ in order to obtain 15 mg Zn and at the same time avoid exceeding the recommended energy intake. The value for the West of Scotland diet is 0·81 μg Zn/kJ. The only items which reach or exceed the recommended value are meats, beverages (mainly the result of tea), nuts, leafy vegetables, eggs and milk. Of these, only the leafy vegetables have a sufficient value for Zn:energy to increase significantly the average value of 0·81 μg/kJ. The adult diet is deficient by 4900 μg; thus if 1 MJ (approximately 3 kg) of cabbage (5 μg Zn/kJ) is consumed at the expense of the 1 MJ of a low-Zn food then the diet would be brought into the recommended Zn–energy balance – but no one would enjoy eating a 3 kg cabbage every day. An alternative is to supplement the diet with inorganic Zn. Inorganic Zn has been administered with success to patients with chronic Zn deficiency (Prasad *et al.* 1963) and to cardiovascular disease patients (Pories *et al.* 1967). However, it is doubtful if the design of the human metabolism could include a requirement for an inorganic Zn supplement. In any case the ingestion of inorganic Zn over prolonged periods of time is likely to upset the balance of Zn with other essential trace elements.

From the dietary information obtained for the West of Scotland the daily family intake of white flour is estimated to be approximately 0·53 kg. White flour has had approximately 800 g Zn/kg removed during the refining process (Schroeder, 1971). Thus if unrefined (i.e. 100% wholemeal) flour is used exclusively in the diet, then the adult male could increase his intake of Zn by approximately 3·5 mg/d and thereby achieve the RDA of 15 mg. The children would similarly achieve their respective RDA.

The RDA for pregnant, lactating and adult women present a particular problem. The 'average' adult woman, if married and eating the same diet as her husband, can never achieve her RDA. The pregnant or lactating woman is in an even less favourable position and must find an additional 5 mg and 10 mg Zn respectively with corresponding increases of 1·3 and 2·1 MJ. The lactating woman must therefore look for a food source providing approximately 5 μg Zn/kJ. The only apparent solution to this is an inorganic Zn supplement.

CONCLUSION

The West of Scotland diet contains less Zn than the recommended daily allowance. This either indicates the need for a revision of the allowances or suggests that a change of diet is necessary. The change could be made simply by the substitution of wholemeal flour for the presently preferred white flour. Other changes in diet could be used but they are unlikely to be acceptable. Even with these changes the requirement of pregnant or lactating women is unlikely to be met and the recommended allowances must either be at fault or these women must have a temporary deficiency as part of their condition.

Over all the study shows that there is no room for complacency about the position of essential trace elements in the diet and that the suggested dietary requirements must be made on a sound basis.

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Printed in Great Britain