*JOURNAL OF THE SCIENTIFIC AGRICULTURAL SOCIETY OF FINLAND*
*Maataloustieteellinen Aikakauskirja*
*Vol. 53:294–301, 1981*

# Intakes of twenty-four mineral elements by Finnish rural children

LEENA RÄSÄNEN[1] and MARJA NUURTAMO[2]

[1] *Department of Public Health, University of Tampere, P. O. Box 607, 33101 Tampere 10*

[2] *Department of Food Chemistry and Technology, University of Helsinki, 00710 Helsinki 71*

**Abstract.** Intakes of twenty-four mineral elements were calculated applying the composition data from the Mineral Element Study (KOIVISTOINEN 1980) to the amounts of food consumed by 1607 Finnish children aged 5, 9 and 13 years (RÄSÄNEN and AHLSTRÖM 1975).

The mean daily intakes of calcium, phosphorus, potassium, magnesium and manganese exceeded the recommended daily intakes in all age groups and that of iron in the 5- and 9-year-old groups. The intakes of zinc, copper, selenium, molybdenum, fluorine and chromium were lower than recommended in all age groups studied. The main sources of minerals were the food groups milk and milk products and cereals and cereal products, which supplied more than 50 per cent of the total intake of most mineral elements.

The intakes of essential mineral elements would increase if the share of refined foods such as dietary fats, sugar and candy were to be decreased in the children's diet.

## Introduction

The need to obtain information about the dietary intakes of mineral elements in various populations has become topical, since many trace elements previously considered non-essential have been shown, during the 1970's, to be essential for animals and man (UNDERWOOD 1977). At the same time, an increasing amount of information has also accumulated about the connections between trace elements and the occurrence of diseases. This has contributed towards an increasing interest in the dietary intakes of mineral elements.

Information has been available about the food consumption and the intakes of energy and certain nutrients among Finnish adults since the first decade of the current century. The first comprehensive survey of children's nutrition was carried out as late as the beginning of the 1970's (RÄSÄNEN et al. 1975). It has been characteristic of the dietary surveys carried out so far in Finland, that of the different mineral elements only the intakes of iron and calcium have been systematically investigated. The reason for this has been that the food composition tables available have not contained information about the contents of other mineral elements in local foods. As far as adults are concerned, however, information about the intakes of some other mineral elements, based on analyses and calculations, have been randomly reported (KOIVISTOINEN et al. 1970, KOSKINEN 1975, HASUNEN et al. 1979).

In 1975—1978 an investigation was carried out in order to shed light on the mineral element composition of Finnish foods (KOIVISTOINEN and VARO 1980). The mineral element compositions of about 450 commonly used foodstuffs were analyzed. The concentrations of the following mineral elements were determined: calcium, phosphorus, potassium, sulphur, magnesium, iron, zinc, manganese, copper, selenium, molybdenum, cobalt, fluorine, chromium, nickel, silicon, arsenic, mercury, lead, cadmium, aluminium, bromine, rubidium and boron.

The dietary intakes of the above 24 macrominerals or trace elements by Finnish rural children are presented in this paper utilizing these composition data.

## Materials and methods

This study was made in connection with a nutrition survey designed to clarify child nutrition in Finland and the relationships between the state of health and food consumption (RÄSÄNEN et al. 1975). The field study was carried out in 14 communes in different parts of the country during the summers of 1970 and 1971. The total material of the nutrition survey consisted of 1658 children aged 5, 9 and 13 years. Complete data on dietary intakes were obtained from 1607 children. The organization of the project, the background data on the children and the results of the physical and biochemical examinations have been presented earlier (RÄSÄNEN et al. 1975, RÄSÄNEN 1977, RÄSÄNEN et al. 1978).

Food consumption was measured by the 24 h recall method (RÄSÄNEN and AHLSTRÖM 1975). The consumption of all solid and liquid foods except the intake of drinking water, coffee and tea was recorded in the interviews. Energy intakes were calculated on the basis of Finnish and foreign food composition tables and analytical data obtained from the manufacturers.

The mineral element intakes were calculated by utilizing the results of the Mineral Element Study (KOIVISTOINEN 1980). No data were available for 44 items out of the total number of 422 different food items present in the diet of the children. In connection with the calculations their mineral element contents were marked as being zero. The proportion of such foodstuffs out of total consumption was. 2.1 %.

The significance of the differences between means was tested by the Student's t test. The product-moment correlation coefficient, r, was calculated as a measure of covariability between two variables. The deviation of the correlation coefficient from zero was tested by the Student's t distribution.

## Results

The mean daily intake of energy and the intakes of mineral elements among children of different ages are shown in Table 1. In the case of most of the mineral elements, intake increased, the older the age group in question. The mean daily intakes of most of the mineral elements in successive age groups deviated from each other highly significantly (P < 0.001). The difference was not significant between the 9- and 13-year-olds in the mean intakes of calcium, selenium, arsenic and mercury. In the case of copper, molybdenum and nickel the average intakes of these age groups deviated from each other almost significantly (P< 0.05) and in the case of silicon significantly (P < 0.01).

The intake of most of the mineral elements was higher (P < 0.001) for boys than for girls. The significance of the difference was lower in the case of silicon and arsenic (P< 0.01) and boron (P< 0.05). Only in the mean intakes of mercury was there no difference between boys and girls.

The energy intake increased (P < 0.001) in the successive age groups of boys (Table 1). The energy intake of 9-year-old girls was higher (P< 0.001) than that of 5-year-olds but did not differ from that of 13-year-old girls (Table 1). When the intakes of mineral elements were calculated per energy content of the diet, most of the differences observed in the absolute intakes disappeared. The diets of girls and boys and of children of different ages thus included practically equal amounts of mineral elements per 10 MJ.

The energy adjusted intake of calcium was lower (P< 0.001) and the intake of cobalt higher (P < 0.001) in each successive age group. In addition, the diets of 9- and 13-year-olds contained more (P < 0.001) iron, manganese, aluminium and cadmium as well as rubidium (P< 0.01) per 10 MJ than the diet of 5-year-olds.

Table 1. Mean daily intakes of energy and mineral elements by age. (Mean values and their standard errors.)

| Nutrient | 5-year-olds n=523 | | 9-year-olds n=589 | | 13-year-olds n=495 | |
|---|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | Mean | SE |
| Energy, MJ | 7.96 | 0.06 | 9.61 | 0.08 | 10.54 | 0.09 |
| Calcium, mg | 1080 | 10 | 1190 | 12 | 1210 | 13 |
| Phosphorus, mg | 1290 | 11 | 1530 | 13 | 1660 | 15 |
| Potassium, mg | 2760 | 24 | 3280 | 29 | 3650 | 32 |
| Sulphur, mg | 606 | 5 | 737 | 6 | 801 | 3 |
| Magnesium, mg | 246 | 2 | 305 | 3 | 351 | 3 |
| Iron, mg | 11.0 | 0.1 | 14.8 | 0.2 | 16.7 | 0.2 |
| Zinc, mg | 9.1 | 0.08 | 11.3 | 0.11 | 12.4 | 0.12 |
| Manganese, mg | 3.8 | 0.07 | 5.0 | 0.07 | 5.9 | 0.08 |
| Copper, mg | 0.9 | 0.01 | 1.3 | 0.03 | 1.5 | 0.03 |
| Selenium, μg | 11.9 | 0.2 | 14.5 | 0.3 | 15.2 | 0.3 |
| Molybdenum, μg | 80 | 1 | 100 | 1 | 100 | 1 |
| Cobalt, μg | 11.0 | 0.1 | 14.5 | 0.2 | 17.0 | 0.2 |
| Fluorine, μg | 270 | 3 | 340 | 4 | 370 | 4 |
| Chromium, μg | 26.7 | 0.3 | 31.2 | 0.3 | 34.9 | 0.4 |
| Nickel, μg | 90 | 2 | 120 | 3 | 130 | 3 |
| Silicon, mg | 20.3 | 0.6 | 26.0 | 0.5 | 30.0 | 0.7 |
| Arsenic, μg | 27 | 0.5 | 33 | 0.6 | 35 | 0.5 |
| Mercury, μg | 3.7 | 0.1 | 4.0 | 0.1 | 4.8 | 0.2 |
| Lead, μg | 39 | 0.5 | 46 | 0.5 | 51 | 0.5 |
| Cadmium, μg | 8.6 | 0.1 | 11.4 | 0.1 | 12.8 | 0.1 |
| Aluminium, mg | 3.8 | 0.04 | 5.0 | 0.06 | 5.6 | 0.06 |
| Bromine, mg | 2.4 | 0.02 | 2.9 | 0.03 | 3.2 | 0.03 |
| Rubidium, mg | 3.1 | 0.03 | 3.6 | 0.03 | 3.9 | 0.04 |
| Boron, mg | 0.9 | 0.01 | 1.0 | 0.01 | 1.1 | 0.01 |

Table 2. Mean daily intakes of foods in grammes and the percentage distribution of the intakes of energy and of mineral elements among different food groups (n=1607)

| Food group intake | Mean daily g | Energy | Ca | P | K | S | Mg | Fe |
|---|---|---|---|---|---|---|---|---|
| Milk and milk products | 720 | 25 | 81 | 47 | 36 | 32 | 28 | 3 |
| Butter, margarine and oils | 47 | 15 | 1 | 1 | 0 | 0 | 0 | 1 |
| Eggs, meat and fish | 132 | 14 | 6 | 17 | 8 | 25 | 7 | 15 |
| Cereal products | 202 | 25 | 5 | 26 | 18 | 31 | 41 | 66 |
| Potatoes and roots | 142 | 5 | 1 | 4 | 22 | 5 | 11 | 7 |
| Vegetables | 70 | 1 | 1 | 2 | 7 | 3 | 4 | 3 |
| Fruits and berries | 120 | 3 | 2 | 2 | 6 | 1 | 4 | 3 |
| Sugar, candy, beverages and other foods | 309 | 12 | 3 | 1 | 3 | 3 | 5 | 2 |

Percentage distribution among food groups

| Food group | Zn | Mn | Cu | Se | Mo | Co | F | Cr | Ni | Si | As | Hg | Pb | Cd | Al | Br | Rb | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk and milk products | 31 | 2 | 7 | 16 | 30 | 8 | 24 | 29 | 9 | 3 | 25 | 17 | 20 | 8 | 16 | 27 | 51 | 16 |
| Butter, margarine and oils | 0 | 0 | 1 | 2 | 0 | 5 | 0 | 7 | 5 | 0 | 0 | 2 | 4 | 4 | 2 | 0 | 1 | 1 |
| Eggs, meat and fish | 23 | 1 | 16 | 59 | 10 | 10 | 12 | 16 | 4 | 6 | 22 | 54 | 11 | 8 | 7 | 13 | 10 | 3 |
| Cereal products | 35 | 71 | 52 | 18 | 20 | 48 | 34 | 25 | 46 | 74 | 19 | 12 | 29 | 46 | 44 | 40 | 16 | 16 |
| Potatoes and roots | 4 | 7 | 10 | 1 | 10 | 10 | 3 | 5 | 9 | 2 | 22 | 7 | 6 | 14 | 9 | 10 | 8 | 21 |
| Vegetables | 3 | 3 | 5 | 1 | 10 | 4 | 3 | 2 | 9 | 3 | 0 | 2 | 2 | 8 | 3 | 1 | 2 | 11 |
| Fruits and berries | 2 | 13 | 6 | 1 | 10 | 3 | 3 | 5 | 9 | 7 | 6 | 3 | 13 | 6 | 7 | 4 | 6 | 25 |
| Sugar, candy, beverages and other foods | 2 | 3 | 3 | 3 | 10 | 12 | 21 | 11 | 0 | 5 | 6 | 3 | 15 | 6 | 12 | 5 | 6 | 7 |

Table 3. Correlations between energy intake and the intakes of mineral elements (n=1607)

| Mineral element | r | Mineral element | r |
|---|---|---|---|
| Calcium | .650 | Fluorine | .744 |
| Phosphorus | .859 | Chromium | .789 |
| Potassium | .780 | Nickel | .348 |
| Sulphur | .883 | Silicon | .283 |
| Magnesium | .818 | Arsenic | .403 |
| Iron | .759 | Mercury | .132 |
| Zinc | .858 | Lead | .719 |
| Manganese | .581 | Cadmium | .774 |
| Copper | .465 | Aluminium | .755 |
| Selenium | .434 | Bromine | .807 |
| Molybdenum | .738 | Rubidium | .879 |
| Cobalt | .754 | Boron | .565 |

The main sources of mineral elements in the diet of Finnish children were the food groups milk and milk products and cereal products (Table 2). These two groups covered 50–85 % of the total intake of most mineral elements. Of the total intake of selenium, arsenic and mercury a considerable proportion was derived from the food group eggs, meat and fish. More than half of the intake of boron was derived from potatoes, vegetables as well as from fruits and berries.

The food group sugar, candy, beverages and other foods supplied at least 10 % of the total intake of molybdenum, cobalt, chromium, lead and aluminium.

Regardless of the fact that 15 % of the total energy intake was derived from food fats, their significance as a source of mineral elements was very small.

The correlation coefficients between energy intake and mineral element intakes (Table 3) all deviated statistically significantly ($P < 0.001$) from zero. With the exception of copper, selenium, nickel, silicon, arsenic and mercury, the variation in the energy intake thus explained at least 30 % of the variation in the intake of each mineral element.

## Discussion

The individual food items were not fully identical in the food consumption survey and in the study on the mineral element composition of foods. Therefore the mineral element contents of certain foodstuffs had to be either calculated or estimated on the basis of the contents in foods closely resembling them or they had to be omitted from the calculations. Such foodstuffs, however, were rare and their consumption so small that the procedure supposedly did not have any noticeable effect on the results.

The mineral elements obtainable from coffee, tea and drinking water also had to be omitted from the calculations, since the consumption of these beverages was not recorded in the dietary interviews. It is, however, possible to make estimates of the additional intakes of the mineral elements obtained from coffee and tea on the basis of data available about the consumption of these beverages by Finnish adolescents (RIMPELÄ and ESKOLA 1980) and on the basis of information about the mineral element composition of coffee and tea (VARO et al. 1980). The concentrations of potassium, magnesium, rubidium and phosphorus are high in coffee while the concentrations of fluorine, manganese, chromium, nickel, aluminium and arsenic are high in tea (VARO et al. 1980). However, owing to the low consumption of coffee and tea the contribution of them to the total intake of these mineral elements is small, less then 5 %. An exception is fluorine, the average intake of which would have been about 7 % higher than that observed in this study if the consumption of tea would have been taken into account.

In order to be able to estimate the contribution of drinking water to the mineral element intakes, data about the mineral element concentrations of water in each community participating in the study would have been necessary, because the concentrations of mineral elements in Finnish waters are known to vary considerably (PUNSAR et al. 1975). In general, the water used for drinking is very soft in Finland. Contribution from water to the total dietary intake is obviously significant only for fluorine, silicon, cadmium and mercury and possibly for magnesium in western Finland and cobalt in eastern Finland (KUMPULAINEN 1981).

The stated daily intakes of mineral elements are group averages. The mineral element intake of individual children may deviate from these figures considerably, depending on the composition of the diet. This is the case especially with those mineral elements which are mainly derived from a few foodstuffs with an exceptionally high content of them. Such mineral elements are, for example, copper, selenium, nickel, silicon, arsenic and mercury, the correlations of which with the energy intake also being smaller than in the case of the other mineral elements examined in the present study.

It should also be noted that the intake of mineral elements may vary from one year to another. For instance, the amount and origin of imported cereals have been observed to have influence especially on the intake of selenium in Finland (VARO and NUURTAMO 1980). The real intake of mineral elements by the children included in the study material may thus, at the time of the study, have deviated from the calculated intake, which was based on analyses carried out on the mineral element composition of foodstuffs in 1975—1978.

Compared with the Recommended Dietary Allowances (ANON. 1980) the mean daily intakes of the macrominerals calcium, phosphorus, potassium and magnesium were adequate, even abundant, in all age groups. Of the trace elements the mean daily intake of manganese clearly exceeded the recommended allowance. The intake of iron exceeded the recommended level in the groups of 5- and 9-year-olds but was below the recommended amount of 18 mg per day among the 13-year-olds. The average intakes of zinc, copper, selenium, molybdenum, fluorine and chromium were, on the other hand, smaller than the recommended daily allowances or the estimated safe and adequate intakes (ANON. 1980). The fact that the intake of certain trace elements among Finnish children was lower than recommended does not, however, necessarily mean that the intake of these trace elements would in fact be inadequate. Further studies concerning these trace elements are necessary.

The intakes of copper, selenium and chromium by Finnish adults have also been observed to be lower than recommended and among women, additionally, the intakes of iron, zinc and molybdenum remain below the recommended level (KOIVISTOINEN et al. 1970, HASUNEN et al. 1979, VARO and KOIVISTOINEN 1980). On the other hand, the diet of not only Finnish children but also that of adults is characterized by a very high content of calcium, potassium, magnesium, phosphorus and manganese (KOIVISTOINEN et al. 1970, KOSKINEN 1975, HASUNEN et al. 1979, VARO and KOIVISTOINEN 1980). This has given cause to pay attention to the risk of possible imbalances in the mutual ratios of mineral elements in the Finnish diet (VARO 1974). The possible effects of this phenomenon on health require further evaluation.

The mean intakes of mercury and cadmium were 15—44 % of the provisional tolerable intakes presented by FAO and WHO (ANON. 1978), the percentages being highest in the youngest age group. The mean daily intake of arsenic was only about 2—3 % of the estimated maximum acceptable load (ANON. 1978).

The mineral element composition of diet calculated per energy content was very similar among children of different ages. The small differences observed in the mineral element concentrations in the diets of children of different ages can be explained by the fact that the proportion of milk and milk products and of fruits and berries decreased with age, while those of fats, cereals and beverages increased (RÄSÄNEN and AHLSTRÖM 1975). Therefore the risk of an inadequate intake of mineral elements is the greater, the smaller the total consumption of food and the intake of energy.

It has been earlier shown that the essential weakness of the diet of Finnish children is the large proportion of fats and sugar (RÄSÄNEN and AHLSTRÖM 1975). As the consumption of refined foods such as dietary fats, sugar and candy increases, the mineral element content of the diet diminishes, because these foods contain very little essential minerals. Thus, to secure an adequate intake of trace elements, it is advisable to aim at decreasing the share of fats and sugar in children's diet.

**Acknowledgements.** The authors gratefully acknowledge the financial grants for this work from the National Research Council for Agriculture and Forestry in Finland.

## References

ANON. 1978. JOINT FAO/WHO CODEX ALIMENTARIUS COMMISSION 1978. List of maximum levels recommended for contaminants by the Joint FAO/WHO Codex Alimentarius Commission. 32 p. CAC/FAL 4-1978.

— , 1980 NATIONAL RESEARCH COUNCIL 1980. Recommended Dietary Allowances. 185 p., 9th Ed., Washington D.C.

HASUNEN, K., SIKKILÄ, K. & AHOLA, M. 1979. Mitä kivennäisainetutkimus paljasti? Kotitalous 43: 385—388.

KOIVISTOINEN, P. 1980. Mineral element composition of Finnish foods: N, K, Ca, Mg, P, S, Fe, Cu, Mn, Zn, Mo, Co, Ni, Cr, F, Se, Si, Rb, Al, B, Br, Hg, As, Cd, Pb and ash. Acta Agric. Scand. Suppl 22:1—171.

— , AHLSTRÖM, A., NISSINEN, H., PEKKARINEN, M. & ROINE, P. 1970. Mineral element composition of Finnish diets. I. Fe, Cu, Mn, Zn, Mg, Na, K, Ca and P. Suomen Kemistilehti B 43: 426—430.

— & VARO, P. 1980. Mineral element composition of Finnish foods. I. General description of the study. Acta Agric. Scand. Suppl. 22: 7—13.

KOSKINEN, E. H. 1975. Suomalaisten ruoankäyttö ja ravinnonsaanti vuosina 1967 . . . 1969 autoklinikan ravintotutkimusten valossa. Kansaneläkelaitoksen julkaisuja ML:6.

KUMPULAINEN, J. 1981. Juomaveden kivennäisaineet ja terveys. EKT-sarja 566, 62 p. Helsinki.

PUNSAR, S., ERÄMETSÄ, O., KARVONEN, M. J., RYHÄNEN, A., HILSKA, P. & VORNAMO, H. 1975. Coronary heart disease and drinking water. A search in two Finnish male cohorts for epidemiologic evidence of a water factor. J. Chron. Dis. 28: 259—287.

RÄSÄNEN, L. 1977. Nutrition survey of Finnish rural children. III. Haemoglobin and haematocrit values. Ann. Clin. Res. 9: 311—313, 1977.

— & AHLSTRÖM, A. 1975. Nutrition survey of Finnish rural children. II. Food consumption. Ann. Acad. Sci. Fenn. A V 169: 1—40.

— , AHLSTRÖM, A. & KANTERO, R-L. 1975. Nutrition survey of Finnish rural children. I. Description of the project, background data and clinical findings. Ann. Acad. Sci. Fenn. A V 168: 1—21.

— , WILSKA, M., KANTERO, R-L., NÄNTÖ, V., AHLSTRÖM, A. & HALLMAN, N. 1978. Nutrition survey of Finnish rural children. IV. Serum cholesterol values in relation to dietary variables. Amer. J. Clin. Nutr. 31: 1050—1056.

RIMPELÄ, M. & ESKOLA, A. 1980. Suomalaisten nuorten kahvin, teen ja kaakaon käyttö. Kotitalous 44: 336—341.

UNDERWOOD, E. J. 1977. Trace elements in human and animal nutrition. 545 p., 4th Ed., New York.

VARO, P. 1974. Mineral element balance and coronary heart disease. Int. J. Vit. & Nutr. Res. 44: 267—273.

— & KOIVISTOINEN, P. 1980. Mineral element composition of Finnish foods. XII. General discussion and nutritional evaluation. Acta Agric. Scand. Suppl. 22: 165—171.

— & NUURTAMO, M. 1981. Selenium in foods and diets. Mineral Elements '80. A Nordic Symposium on Soil-Plant-Animal-Man Interrelationships and Implications to Human Health. December 9—11, 1980, Helsinki—Espoo. Proceedings, p. 545—555, Helsinki.

— , NUURTAMO, M., SAARI, E. & KOIVISTOINEN, P. 1980. Mineral element composition of Finnish foods. IX. Beverages, confectionaries, sugar and condiments. Acta Agric. Scand. Suppl. 22: 127—139.

Ms received November 6, 1981.

# Suomalaisten maalaislasten kivennäisaineiden saanti

Leena Räsänen[1] ja Marja Nuurtamo[2]

[1] *Tampereen yliopiston kansanterveystieteen laitos, 33101 Tampere 10*
[2] *Helsingin yliopiston elintarvikekemian ja -teknologian laitos, 00710 Helsinki 71*

Tutkimuksessa laskettiin ruoankulutustietojen (RÄSÄNEN and AHLSTRÖM 1975) perusteella 1607:n 5-, 9- ja 13-vuotiaan maalaislapsen kivennäisaineiden saanti. Tiedot tutkimuksen kohteena olleiden 24 kivennäisaineen pitoisuudesta elintarvikkeissa perustuivat Kivennäisainetutkimuksessa (KOIVISTOINEN 1980) saatuihin analyysituloksiin.

Kalsiumin, fosforin, kaliumin, magnesiumin ja mangaanin keskimääräinen päiväsaanti ylitti saantisuosituksen kaikissa ikäryhmissä, ja raudan saanti 5- ja 9-vuotiaiden ryhmissä. Sinkin, kuparin, seleenin, molybdeenin, fluorin ja kromin saanti oli suositusta vähäisempää kaikissa tutkituissa ikäryhmissä. Tärkeimmät kivennäisaineiden lähteet lasten ruokavaliossa olivat maito ja maitovalmisteet sekä viljavalmisteet, jotka yhdessä kattoivat 50—85 % useimpien kivennäisaineiden kokonaissaannista. Seleenin, arseenin ja elohopean kokonaissaannista oli merkittävä osa peräisin lihasta, kalasta ja munasta.

Kaikkien välttämättömien kivennäisaineiden riittävän saannin turvaamiseksi on syytä pyrkiä vähentämään raffinoitujen, energiasisältöönsä nähden vain hyvin vähän kivennäisaineita sisältävien elintarvikkeiden kuten rasvojen, sokerin ja makeisten osuutta lasten ruokavaliossa.