Int. J. Vitam. Nutr. Res., 71 (6), 2001, 356–363

# Significance of Fortified Beverages in the Long-term Diet of German Children and Adolescents: 15-Year Results of the DONALD Study

Wolfgang Sichert-Hellert and Mathilde Kersting

Research Institute for Child Nutrition (FKE) Dortmund, Germany

Received for publication: June 28, 2001

**Abstract:** Fortified beverages and instant drinks are the most frequently consumed fortified products in children and adolescents in Germany. However, little is known about the contribution of these products to micronutrient intake. Between 1986 and 2000, consumption of fortified food (total and the subgroup of fortified beverages) and time trends in energy and micronutrient intake were assessed on the basis of 3 day-weighed dietary records (n = 4358) of males and females between the ages of 2 and 14 years (n = 398/408) enrolled in the DONALD Study (Dortmund Nutritional and Anthropometric Longitudinally Designed Study). As percentage of recent references for micronutrient intake, a significant increase in intake from fortified beverages was observed for calcium (from 1 to 3%), iron (3 to 4%), vitamin A (5 to 15%), and vitamin C (5 to 60%). Significant increases in intakes were only observed from 1995–1997 for vitamin E, folate, and niacin (all 5 to 15–25%), vitamin $B_1$ and $B_2$ (both 10–15 to 25–30%) and vitamin $B_6$ (20 to 55%). Thereafter significant decreases were found. Among the fortified beverages, juice was the most important for micronutrient intake, followed by soft drinks (calcium, vitamin A, E, C, folate, niacin) or by instant beverages (energy, iron, vitamin $B_1$, $B_2$, $B_6$). Significant linear and nonlinear time trends in micronutrient intakes from fortified food and fortified beverages were observed in German children and adolescents.

**Key words:** Fortified food, fortified beverages, children, adolescents, vitamin intake, mineral intake, dietary records

## Introduction

In Germany, the fortification of food started with multivitamin juices in the early 1980s. Fortified beverages are still the food group with the greatest variety of products or brands. Fortified milk products were introduced in Germany early as fortified beverages, but in diversity they remained comparatively small. Although fortified products play an important role in food marketing in Germany, data as to the consumption of fortified food is not available.

Furthermore, long-term data on changes in fortified food supply or consumption patterns are available for neither adults nor children and adolescents. In two previous evaluations of the DONALD Study (**D**ortmund **N**utritional and **A**nthropometric **L**ongitudinally **D**esigned Study), we reported that fortified beverages and instant drinks were the most frequently consumed fortified products in children and adolescents in Germany [1] and that vitamin and mineral intake from fortified food has increased over a ten-year period [2].

In the present paper we compare data on energy and micronutrient intake from total food and from subgroups of fortified food and fortified beverages in 2- to 14-year-old participants from the DONALD Study, with the new German, Austrian and Swiss references (DACH) for micronutrient intake [3] and on 15-year time trends between 1986 and 2000.

## Subjects and methods

The sample was taken from the DONALD Study; details have been described elsewhere [2]. The study is purely observational and noninvasive as approved by the International Scientific Committee of the Research Institute of Child Nutrition. In short, the DONALD Study is a cohort study collecting detailed data on diet, metabolism, growth and development from healthy subjects between infancy and adulthood (once a year for subjects older than 2 years). The study started in the middle of 1985 with children and adolescents of different ages participating until then in exclusively anthropometric studies at our institute. Since then, yearly cohorts of about 40 to 50 healthy infants have been enrolled. Mothers are recruited in maternity wards or are informed by other study participants. In the DONALD Study, sample upper-social-class families are overrepresented. About 35 (45)% of the mothers (fathers) have a grammar school education and 21 (39)% hold a university degree or a professional qualification [4].

Food consumption was assessed with 3 day-weighed dietary records as described elsewhere [2, 4]. Parents of the children or the older subjects themselves weighed and recorded all foods and fluids consumed, as well as unconsumed leftovers, using electronic food scales (± 1 g). Product information from wrappers, cartons, etc. were kept and evaluated by our dieticians. Semi-quantitative recording (e.g. numbers of cups, spoons) was allowed if weighing was not possible. However, in 75% of the completed records, more than 90% of the food items were weighed. Weekdays (68%) and weekend days (32%) were proportionally distributed in the sample. To validate dietary recording, the ratio of reported energy intake (EI) and predicted basal metabolic rate (BMR) was calculated [5].

Nutrient contents of common foods were taken from standard nutrient tables. Those of commercial food products were determined either by using the product labels or by simulating recipes from the ingredients listed. Nutrient and water contents of all recorded food items were entered in a nutrient data base "LEBTAB" (about 4000 different items). Food products were defined as fortified if enriched with at least one of the following micronutrients: vitamin A or provitamin A carotenoids (summarized as vitamin A), vitamins E, $B_1$, $B_2$, $B_6$, C, niacin, folate, calcium or iron. Fortified beverages were grouped into juice (100% fruit), soft drinks (juice < 100% fruit, carbonated and others), instant drinks, and milk (as a beverage). Nutrient supplements and medicine containing nutrients were excluded.

SAS, procedures (Version 6.12) were used for data analysis. Energy and micronutrient intakes were calculated as individual means of the 3 recorded days. Results are presented as mean values ± SD. To analyse the influence of effects (year, year × year, age, sex) on the outcome variables, a mixed linear model was used, in which the means of the data and the covariance structure (children of the family, repeated measurements) were modelled (PROC MIXED). An exponential structure of covariance was specified to consider correlation of repeated measurements dependent on the absolute time interval of repeated measurements within the same subject.

Fixed effects were noted (see β1 and β2 in Table III): increase (+), decrease (–).

## Results

Between 1986 and 2000 a total of 4358 dietary records from 806 subjects (398 males, 408 females) aged 2 to 14 years were collected and evaluated. On average, 5 records per participant were available and 290 subjects participated per year with a mean age of 7.2 ± 3.5 years (Table I). Overall energy intake was 1517 ± 425 kcal/d. The mean EI:BMR-ratio of the sample of 1.43 ± 0.25 (Table I) was within the recommended range of plausible dietary information [6]. Overall total intake of minerals and vitamins studied here are summarised in Table I.

### Overall mineral and vitamin intake as % of references

Compared with the references [3], seven out of 10 micronutrients showed total intake levels of about 90% and more, but folate, and to some extent vitamin E and iron, had lower intake levels in our study (Fig. 1). Micronutrient intake data from fortified food reveal four clusters: a) 70% of the references for vit. $B_6$; b) about 40% for vitamin C, $B_1$, $B_2$, E, and niacin; c) about 20% for vitamin A and folate; d) under 10% for iron and calcium respectively.

*Table I:* Age, energy and micronutrient intakes (total, as % of references) in 2–14 year-old participants of the DONALD Study between 1986 and 2000 (n = 4358 records, mean ± sd)

| | Mean | ± Sd | Mean | ± Sd |
|---|---|---|---|---|
| Age, years | 7.2 | 3.5 | | |
| Energy, kcal/d | 1517 | 452 | | |
| Energy, kcal/kg Body Weight/d | 61.1 | 16.9 | | |
| Energy/BMR* | 1.43 | 0.25 | | |
| | Micronutrient intake | | as % of references | |
| Calcium, mg/d | 741 | 284 | 91 | 32.2 |
| Iron, mg/d | 8.2 | 2.8 | 84 | 24.0 |
| Vit. A, mg/d | 0.67 | 0.43 | 88 | 54.5 |
| Vit. E, mg/d | 7.1 | 4.7 | 80 | 48.8 |
| Vit. C, mg/d | 97 | 66 | 128 | 84.2 |
| Vit. $B_1$, mg/d | 0.92 | 0.55 | 103 | 55.3 |
| Vit. $B_2$, mg/d | 1.3 | 0.7 | 130 | 61.9 |
| Vit. $B_6$, mg/d | 1.2 | 0.7 | 191 | 105.5 |
| Niacin, mg/d | 20 | 8 | 179 | 60.3 |
| Folate, mg/d | 145 | 101 | 48 | 31.2 |

* BMR = Basic Metabolic Rate

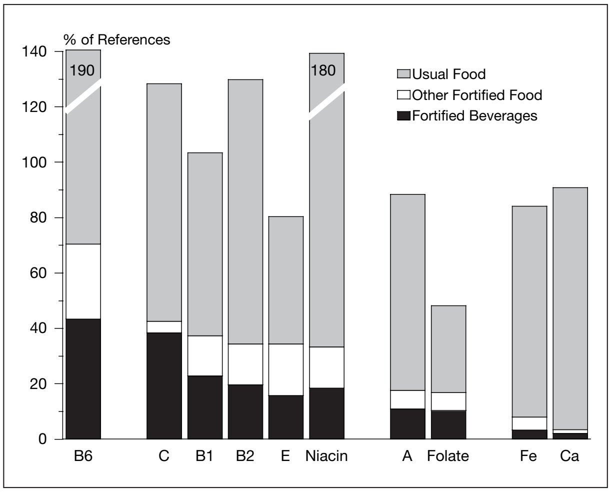


*Figure 1:* Micronutrient intake as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

Fortified beverages alone accounted for about 40% of references for vitamins $B_6$ and C; about 20% for vitamins $B_1$, $B_2$, E, and niacin; about 10% for vitamin A and folate; and less than 5% for iron and calcium respectively. Ranking the overall contributions of different types of fortified beverages reveals the dominance of fortified juice, whereas the other types of fortified beverages (with added sugars) showed two clusters: a) soft drinks were more important than instant products and milk for vitamin A, E, C, folate, niacin, and calcium intake, and b) instant products were more important than soft drinks and milk for vitamin $B_1$, $B_2$, $B_6$, iron, and energy intake (Table II).

*Table II:* Mean contributions of fortified beverages to total micronutrient intakes as % of references [3] (energy: as % of total energy) in 2–14 year-old participants of the DONALD Study ranked in subgroups by total

| | Juice % | Soft Drinks % | Instant % | Milk % | Total % |
|---|---|---|---|---|---|
| Vit. C | 24.2 | 10.0 | 4.1 | 0.1 | 38.4 |
| Niacin | 11.4 | 3.9 | 2.6 | 0.5 | 18.4 |
| Vit. E | 9.2 | 4.0 | 2.1 | 0.5 | 15.8 |
| Vit. A | 7.3 | 2.0 | 0.2 | 1.5 | 11.0 |
| Folate | 6.9 | 2.3 | 1.0 | 0.2 | 10.4 |
| Calcium | 0.8 | 0.6 | 0.4 | 0.3 | 2.1 |
| Vit. $B_6$ | 23.9 | 7.8 | 10.3 | 1.4 | 43.4 |
| Vit. $B_2$ | 12.9 | 2.5 | 3.2 | 1.0 | 19.6 |
| Vit. $B_1$ | 12.3 | 4.1 | 5.8 | 0.7 | 22.9 |
| Iron | 1.8 | 0.5 | 0.9 | 0.1 | 3.3 |
| Energy | 1.4 | 0.7 | 0.9 | 0.1 | 3.1 |

## Time trends in energy and micronutrient intake

During the entire 15-year period of the DONALD Study, there was no significant time trend in total energy intake. There was a significant time trend in total micronutrient intake only for iron and vitamin A expressed as percentage of references. However, a significant linear increase for vitamin C and significant nonlinear intakes for calcium, vitamin E, $B_1$, $B_2$, $B_6$, niacin, and folate as percentage of references were found (Table III).

In the 15-year study period, energy intake from fortified beverages as percentage of total energy intake increased significantly (from 2 to 3%; Fig. 2). Micronutrient intake from fortified beverages as percentage of references increased significantly for calcium (from 1 to 3%; Fig. 3), for iron (from 3 to 4%; Fig. 4), for vitamin A (from 5 to

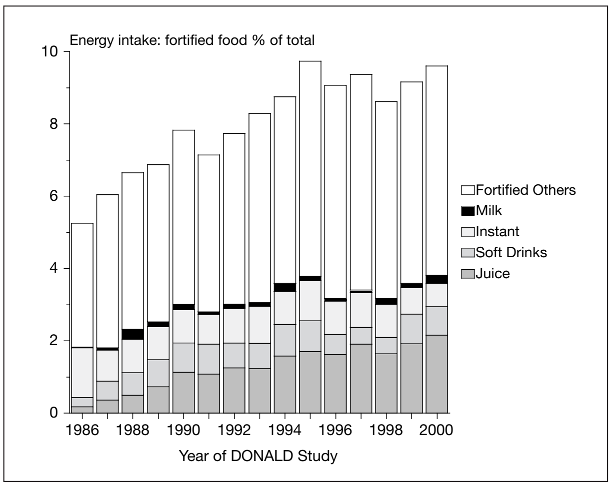


*Figure 2:* Energy intake with fortified food as % of total energy intake in 2–14 year-old participants of the DONALD Study (n = 4358 records).

*Table III:* 15-year-time-trend analysis (β1, β2, p-values) for energy and micronutrient intakes with total food and fortified beverages in 2–14 year-old participants of the DONALD Study (as % of references, except energy)

| Effects | Energy | | Iron | | Calcium | | Vit. A | | Vit. C | |
|---|---|---|---|---|---|---|---|---|---|---|
| | β | p | β | p | β | p | β | p | β | p |
| *Total food* | | | | | | | | | | |
| Year (β1)[a] | 0.34 | 0.82 | 0.02 | 0.89 | 3.18 | 0.0001 | 0.16 | 0.51 | 2.18 | 0.0001 |
| Year × Year (β2)[b] | – | – | – | – | –0.16 | 0.0001 | – | – | – | – |
| Sex | | 0.0001 | | 0.0001 | | 0.0001 | | 0.06 | | 0.40 |
| Age | | 0.0001 | | 0.0008 | | 0.0001 | | 0.003 | | 0.02 |
| Fortified beverages | | | | | | | | | | |
| Year (β1)[a] | 2.11 | 0.0001 | 0.15 | 0.0001 | 0.19 | 0.0001 | 0.65 | 0.0001 | 2.57 | 0.0001 |
| Year × Year (β2)[b] | – | – | – | – | – | – | – | – | – | – |
| Sex | | 0.09 | | 0.39 | | 0.31 | | 0.74 | | 0.47 |
| Age | | 0.06 | | 0.0001 | | 0.0003 | | 0.28 | | 0.0001 |

| Effects | Vit. E | | Vit. $B_1$ | | Vit. $B_2$ | | Vit. $B_6$ | | Niacin | | Folate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | p | β | p | β | p | β | p | β | p | β | p |
| Total food | | | | | | | | | | | | |
| Year (β1)[a] | 5.5 | 0.0001 | 5.33 | 0.0001 | 6.73 | 0.0001 | 11.78 | 0.0001 | 5.76 | 0.0001 | 1.96 | 0.0001 |
| Year × Year (β2)[b] | –0.30 | 0.0001 | –0.27 | 0.0001 | –0.38 | 0.0001 | –0.55 | 0.0001 | –0.24 | 0.0001 | –0.12 | 0.0002 |
| Sex | | 0.26 | | 0.02 | | 0.0005 | | 0.0001 | | 0.0001 | | 0.02 |
| Age | | 0.02 | | 0.25 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.36 |
| Fortified beverages | | | | | | | | | | | | |
| Year (β1)[a] | 3.12 | 0.0001 | 4.38 | 0.0001 | 4.79 | 0.0001 | 8.23 | 0.0001 | 4.08 | 0.0001 | 2.62 | 0.0001 |
| Year × Year (β2)[b] | –0.14 | 0.0004 | –0.21 | 0.0001 | –0.25 | 0.0001 | –0.37 | 0.0001 | –0.17 | 0.0001 | –0.15 | 0.0001 |
| Sex | | 0.24 | | 0.97 | | 0.75 | | 0.60 | | 0.91 | | 0.79 |
| Age | | 0.22 | | 0.42 | | 0.49 | | 0.0001 | | 0.14 | | 0.92 |

Bold type: Significant effects; p: p-values

[a] β1: linear time trend weighted least square estimates; Example Vit. C (β1 = 2.18): a (significant) increase of 2.18% (vit. C intake as % of references) per year.

[b] β2: quadratic time trend weighted least square estimates; Example Calcium (β1 = 3.18 and β2 = –0.16): a (significant) increase of 3.18% (calcium intake as % of references) per year minus 0.16% multiplied by year$^2$.

p: p-values.

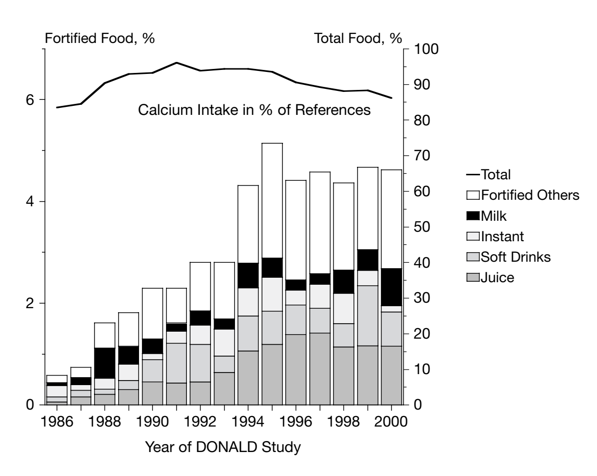


*Figure 3:* Calcium intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

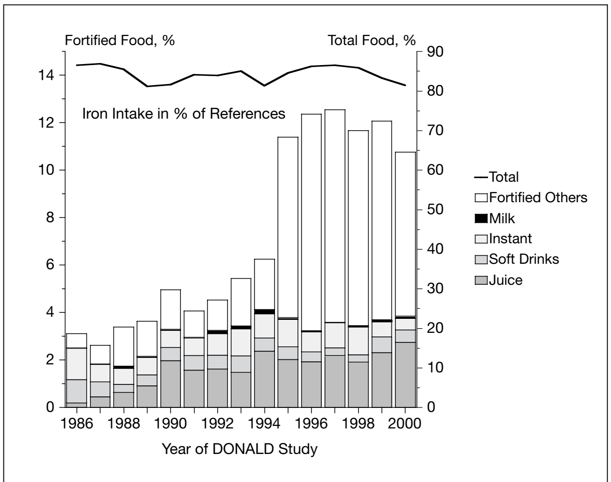


*Figure 4:* Iron intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

15%; Fig. 5), and for vitamin C (from 15 to 60%; Fig. 6; Table III). However, significant increases in intakes were only observed from 1995–1997 for vitamin E (Fig. 7), folate (Fig. 8), and niacin (all 5 to 15–25%), vitamin $B_1$ (Fig. 9) and $B_2$ (both 10–15% to 25–30%) and vitamin $B_6$ (20 to 55%). After 1997, significant decreases were found (Table III). Figures for vitamin $B_2$, $B_6$ and niacin, all similar to vitamin $B_1$ (cf. Fig. 9), are not shown.

**Importance of fortified beverages within total fortified food consumption**

With the exception of vitamin E and iron, fortified beverages accounted for more than 50%, and in the case of vitamin C up to 90%, of micronutrient intake from total fortified food. However, the contribution of single types of fortified beverages to total intake remained quite small. As percentage of references, fortified juice was the most important beverage with a maximum of 24% (vitamin C, $B_6$) to total micronutrient intake (Table III) followed by soft drinks with a maximum of 10% (vitamin C) and instant drinks with a maximum of 10% (vitamin $B_6$). Fortified milk never had intake levels over 3% of the references in single years.

## Discussion

The DONALD Study is a longitudinal, non-intervening study. Uniform methodology, including 3-day dietary

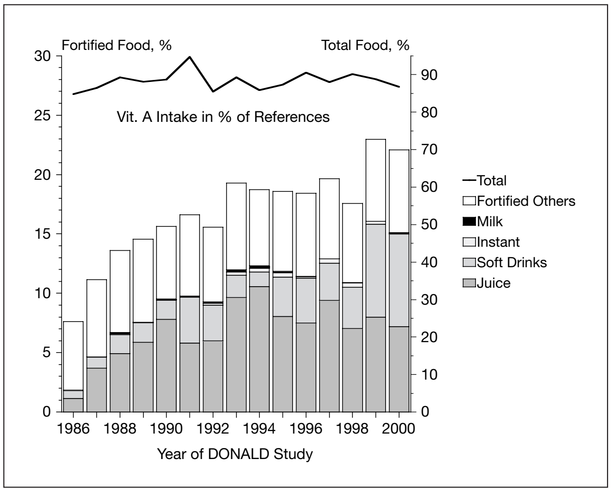


*Figure 5:* Vitamin A intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

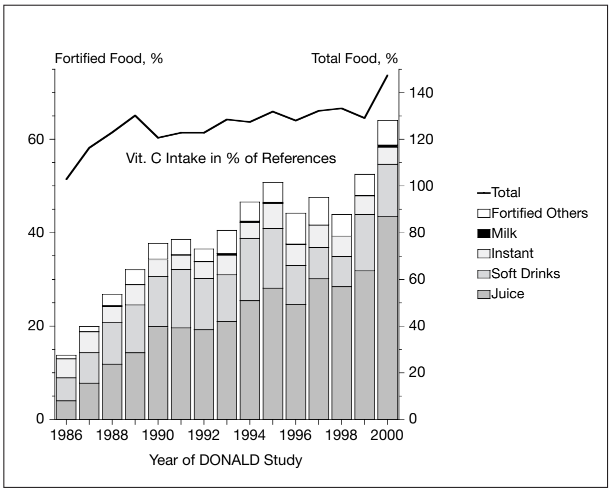


*Figure 6:* Vitamin C intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

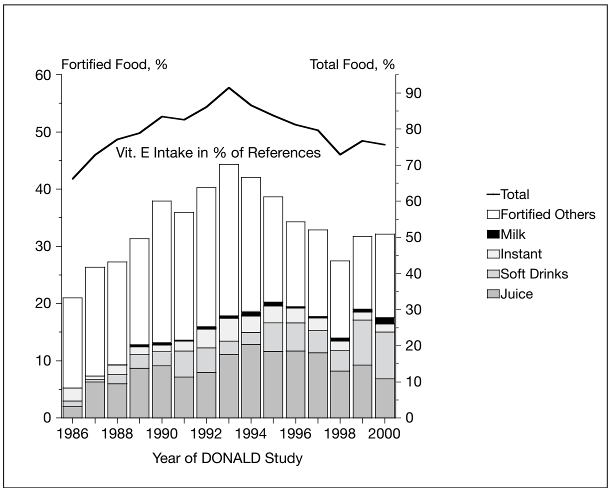


*Figure 7:* Vitamin E intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

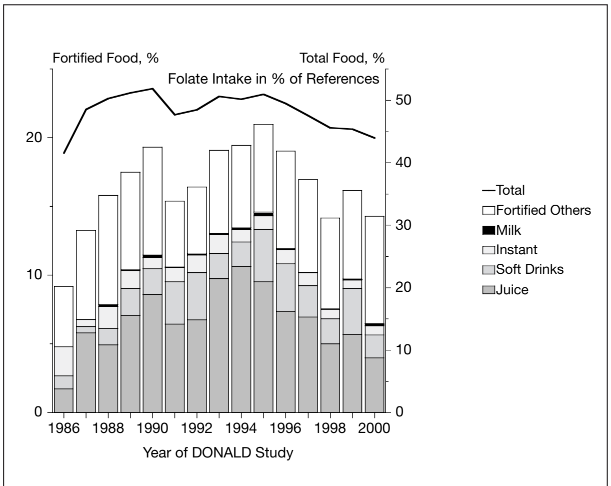


*Figure 8:* Folate intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

records and a nutrient database containing fortified food items, was used throughout the study. This offers a differentiated insight into micronutrient intake and consumption patterns of fortified food – especially the role of fortified beverages – in German children and adolescents.

In the literature, only a few studies are concerned with the consumption of fortified food. Some are confined to single food groups such as breakfast cereals [7–11] while others focus on nutrient intake from fortification in adults [12–14]. Long-term data on fortified food consumption patterns in German children and adolescents has also been reported [1, 2].

### Total nutrient intake

Total nutrient intakes in the DONALD Study are almost as high as those found in other representative cross-sectional European studies using dietary records, e.g. in the Netherlands [15], in Greece [16], in Spain [11], and in England [17]. Compared to the new DACH references [3], micronutrient intakes in our population were almost adequate, with the exception of low intakes for folate and vitamin E.

### Micronutrient intake from fortified food

Our data show a wide range of micronutrient intake from fortified food. In general fortified foods are less important sources for minerals than for vitamins. The situation for fortified vitamins differed considerably. Some foods (e.g., in the case of vitamin A and folate) showed only minor contributions to micronutrient intake while most others (e.g. vitamin E, $B_1$, $B_2$, $B_6$, niacin) were more important. For some micronutrients, fortification was unnecessary (vitamin $B_2$, $B_6$, niacin) or inefficient (calcium, iron). In the case of vitamin A, E and folate (and to some extent vitamin $B_1$), fortification was necessary to improve micronutrient supply in our sample.

### Time trends

The most striking results of our study are signs of changing food consumption patterns, pointing to an almost uniform increase of micronutrient intake between 1986 and 1996 followed by a decrease thereafter [18]. With the exception of vitamin A and iron – without any time trend at all – we found a significant increase of + 1.4%/year for vitamin C, but a significant decrease for total intake in calcium and 6 vitamins ( E, $B_1$, $B_2$, $B_6$, niacin, and folate). Moreover, our evaluation of the contribution of fortified

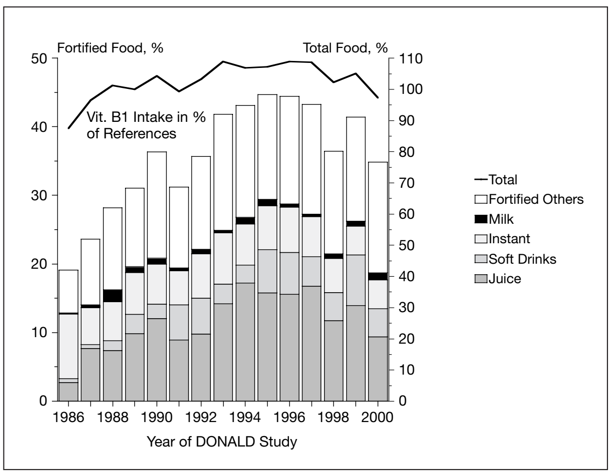


*Figure 9:* Vitamin B1 intake with fortified and total food as % of references [3] in 2–14 year-old participants of the DONALD Study (n = 4358 records).

beverages showed a significant decrease in the same 6 vitamins since 1994/96. Together with the observed increase of added sugars from fortified food [2] this points to a slight but unfavorable tendency to eat energy-dense, nutrient-poor foods (EDNP) in our study population – reported recently in an evaluation of NHANES III too [19]. Possible explanations for the time trend found are a similar nonlinear trend in the number of simultaneously fortified micronutrients per product, a trend to lower mean dosages of fortified micronutrients, changing product preferences of the study participants, and an almost stable level of energy intake from total fortified food as well as fortified beverages after 1995 (cf. Fig. 2). The only roughly comparable longitudinal study in children and adolescents originates from the Netherlands [15], where total micronutrient intake (calcium, iron, vitamins A and C) was assessed at 3 time points in 1987/88, 1992 and 1997/98. Compared with the new references [3], these intake data confirm our findings reported here.

Our evaluation underlines the dominance of fortified beverages as a part of fortified food in micronutrient intake in children and adolescents. Except in the case of vitamin E and iron, fortified beverages account for more than 50% of micronutrient intake from total fortified food. Furthermore, fortified beverages improve micronutrient supply for vitamins A, E, and folate in our sample. However, for vitamins $B_2$, $B_6$, and niacin, and to some extent for vitamins $B_1$ and C, fortification seems unnecessary. When assessing the nutritional valuation of fortified beverages it should be taken into account that with the exception of fortified juice (100% fruit), all other fortified beverages contain added sugars.

## Acknowledgments

We are very grateful to Christa Chahda and Ruth Schäfer for collecting and coding the dietary records in the DONALD-Study and to Diane Pavlitzek for proof reading.

# References

1. Sichert-Hellert, W., Kersting, M. and Schöch, G. (1999) Consumption of fortified food between 1985 and 1996 in 2- to 14-year-old German children and adolescents. Int. J. Food Sci. Nutr. 50, 653–659.
2. Sichert-Hellert, W., Kersting, M., Alexy, U. and Manz, F. (2000) Ten-year trends in vitamin and mineral intake from fortified food in German children and adolescents. Eu. J. Clin. Nutr. 54, 81–86.
3. Deutsche Gesellschaft für Ernährung (DGE) (2000) Referenzwerte für die Nährstoffzufuhr. Umschau/Braus, Frankfurt am Main (in German).
4. Kersting, M., Sichert-Hellert, W., Lausen, B., Alexy, U., Manz F. and Schöch G. (1998) Energy intake of 1 to 18 year old German children and adolescents. Z. Ernährungswiss. 37, 47–55 (in English).
5. Goldberg, G.R., Black, A.E., Jebb, S.A., Cole, T.J., Margatroyd, P.R. and Coward, W.A. (1991) Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify underrecording. Eur. J. Clin. Nutr. 45, 569–581.
6. Torun, B., Davies, P.S.W., Livingstone, M.B.E., Paolisso, M., Sackett, R. and Spurr, G.B. (1996) Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. Eur. J. Clin. Nutr. 50, Suppl 1, S37–S81.
7. Morgan, K.J., Zabik, M.E. and Leveille, G.A. (1981) The role of breakfast in nutrient intake of 5- to 12-year-old children. Am. J. Clin. Nutr. 34, 1418–1427.
8. McNulty, H., Eaton-Evans, J., Cran, G., Woulahan, G., Boreham, C., Savage, J.M., Fletcher, R. and Strain, J.J. (1996) Nutrient intakes and impact of fortified breakfast cereals in schoolchildren. Arch. Disease Childhood. 75, 474–481.
9. Nicklas, T.A., Myers, L. and Berenson, G.S. (1995) Total nutrient intake and ready-to-eat cereal consumption of children and young adults in the Bogalusa Heart Study. Nutr. Rev. 53, Suppl, S39–S45.
10. Moynihan, P., Adamson, A., Rugg-Gunn, A., Appleton, D. and Butler, T. (1996) Dietary sources of calcium and the contribution of flour fortification to total calcium intake in the diets of Northumbrian adolescents. Brit. J. Nutr. 75, 495–505.
11. Ortega, R.M., Requejo, A.M., Redondo, R., López-Sobaler, A.M., Andrés, P., Ortega, A., Gapar, M.J., Quintas, E. and Navia, B. (1996) Influence of the intake of fortified breakfast cereals on dietary habits and nutritional status of Spanish schoolchildren. Ann. Nutr. Metabol. 40, 146–156.
12. Subar, A.F., Bowering, J. (1988) The contribution of enrichment and fortification to nutrient intake of women. J. Am. Diet. Assoc. 88, 1237–1245.
13. Stanton, J.L. and Keast, D.R. (1989) Serum cholesterol, fat intake, and breakfast consumption in the United States adult population. J. Am. Coll. Nutr. 8, 567–572.
14. Block, G., Sinha, R. and Gridley, G. (1994) Collection of dietary-supplement data and implications for analysis. Am. J. Clin. Nutr. 59, Suppl, 232S–239S.
15. Anonymous (ed.) Zo eet Nederland. (1998) Resultaten van de Voedselconsumptiepeiling 1997/1998. Delft Drukkers (in Dutch – Tables in English) ISBN 90 5177 0367.
16. Roma-Giannikou, E., Adamidis, D., Gianniou, M., Nikolara, R. and Matsaniotis, N. (1997) Nutritional survey in Greek children: nutrient intake. Eur. J. Clin. Nutr. 51, 273–285.
17. Nelson, M., Naismith, D.J,, Burley, V., Gatenby, S. and Geddes, N. (1990) Nutrient intakes, vitamin-mineral supplementation, and intelligence in British schoolchildren. Brit. J. Nutr. 64, 13–22.
18. Sichert-Hellert, W., Kersting, M. and Manz, F. (2001) Changes in time-trends of nutrient intake from fortified and non-fortified food in German children and adolescents – 15 Year Results of the DONALD Study. Eu. J. Nutr. 40, 49–55.

19. Kant, A. K. (2000) Consumption of energy-dense, nutrient-poor foods by adult Americans. Am. J. Clin. Nutr. 72, 929–936.
20. Sichert-Hellert, W., Kersting, M. and Manz, F. (2001) Fifteen-year trends in water intake in German children and adolescents: results of the DONALD study. Acta Paediatr. 90, 732–737.

Dr. Wolfgang Sichert-Hellert

Research Institute for Child Nutrition (FKE)
Heinstueck 11
D-44225 Dortmund
Germany