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Use of voluntarily fortified foods among adults in Finland

Tero Hirvonen[1,*], Anna Kara[2], Liisa Korkalo[2], Harri Sinkko[3], Marja-Leena Ovaskainen[3] and Vera Mikkilä[2]

[1]Finnish Food Safety Authority, Risk Assessment Unit, Mustialankatu 3, FI-00790 Helsinki, Finland: [2]Department of Food and Environmental Sciences, University of Helsinki, Helsinki, Finland: [3]Department of Lifestyle and Participation, National Institute for Health and Welfare (THL), Helsinki, Finland

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Abstract

Objective: To investigate the purchase and use of fortified foods, and to explore and compare background characteristics, food consumption and nutrient intakes among users and non-users of voluntarily fortified foods in Finland.

Design: A study based on the National FINDIET Survey 2007 (48 h recall), which included also a barcode-based product diary developed to assess the type, amount and users of voluntarily fortified foods. Logistic regression analysis was employed to investigate associations between background characteristics and the use of fortified foods.

Setting: Randomly chosen subgroup of 918 adult participants in the National FINDIET 2007 Survey.

Subjects: Men and women aged 25–64 years from five regions.

Results: The product group of voluntarily fortified foods purchased in the highest volume was yoghurts (44 % of the weight of all fortified food), followed by fruit drinks (36 %). The only characteristics independently associated with the use of voluntarily fortified foods were age (older people used them less commonly) and the consumption of fruit and vegetables (participants with the highest consumption used them more commonly). Users of fortified foods had higher consumption of yoghurt, juice drinks and ready-to-eat breakfast cereals (women only) than non-users, and lower consumption of boiled potatoes (men only).

Conclusions: Use of voluntarily fortified foods is associated with high consumption of fruit and vegetables but not with other health-related behaviours. The use of voluntarily fortified foods does not seem to even out the differences in nutrient intake among Finnish adults.

Keywords
Fortification
Adults
Food products

It is possible to increase nutrient intakes markedly in a population via food fortification[1], and mandatory fortification has been used with success as a means to reduce nutritional deficiencies (e.g. iodising of table salt to reduce the incidence of iodine-deficiency disorders). On the other hand, fortification of foods may also create a risk of exceeding the upper acceptable intake limit and in extreme cases a risk of poisoning. Increasing nutrient intake via fortification is safe when sufficiently targeted at those with low vitamin and mineral intakes[2].

Before accession to the EU, food fortification in Finland was strictly regulated, with fortification applied to reduce nutritional deficiencies. After joining the EU, Finland started to liberalise fortification of foods and it was approved by the authorities unless there was a risk of overdose[3]. Food fortification was legally based on either of the following: (i) general regulation in which all permitted food-group–nutrient-concentration combinations were enumerated (e.g. milk could be fortified with vitamin D in a concentration of 0·5 μg/100 g), which covers widespread fortification (in which almost all products in a food group are fortified), including that of margarines with vitamins A and D, fortification of milk with vitamin D, and iodisation of table salt; and (ii) special permission granted by the Finnish Food Safety Authority for other food-group–nutrient-concentration combinations than mentioned in the general regulation. At the moment, there are two types of food fortification in use in Finland: (i) 'common-practice fortification', performed in consensus between the authorities and the food industry, that covers almost all products in a food group (e.g. milk's fortification with vitamin D); and (ii) 'voluntary fortification', which is carried out by each individual food producer and is regulated only by the common EU regulation on food fortification (Regulation (EC) 1925/2006). The data for the present study were collected before the latest EU regulation entered into force (July 2007) but after Finland joined the EU. Voluntary fortification has become increasingly common in Finland

*Corresponding author: Email terohirvonen69@gmail.com

and most often stems from commercial interests rather than public health needs. In the present study, voluntary food fortification is deemed to consist of all fortification apart from common-practice fortification.

Voluntary fortification is sometimes used to increase the nutritional acceptability of foods whose nutritional profile is often low – i.e. foods that are low in mineral content, fibre and vitamins, but high in sugar, saturated fats or salt[4]. However, little is known of what kinds of voluntarily fortified foods are most commonly used and who the users of fortified foods are. Also, the true consumption of these foods may be difficult to capture via conventional dietary assessment methods, because consumers may not always be aware of the fortification of the foods purchased and consumed and may not remember the exact name of the product when reporting their food consumption.

The three aims of the present study were: (i) to investigate the type and amount of voluntarily fortified foods consumed by Finnish adults; (ii) to examine and compare background characteristics, food consumption and nutrient intakes among users and non-users of voluntarily fortified foods; and (iii) to evaluate whether users and non-users of foods fortified with a specific nutrient have a differing total intake of that nutrient from ordinary foods and food supplements alone – i.e. whether fortification is diminishing real differences in nutrient intake. In addition, we introduce a new tool developed for collecting detailed data on the purchase and use of food products.

Methods

Data on the consumption of food and food supplements and on the use of voluntarily fortified foods were obtained from the National FINDIET 2007 Survey, carried out as part of the FINRISK 2007 Study, which monitors cardiovascular risk factors in Finland (Fig. 1)[5]. A random sample of 9958 persons aged 25–74 years, in five areas, stratified by sex, area and 10-year age band, was taken from the population register. The study areas were: (i) the Helsinki and Vantaa metropolitan area; (ii) the areas of Turku and Loimaa, in south-west Finland; and the provinces of (iii) North Karelia, (iv) North Savo and (v) Oulu.

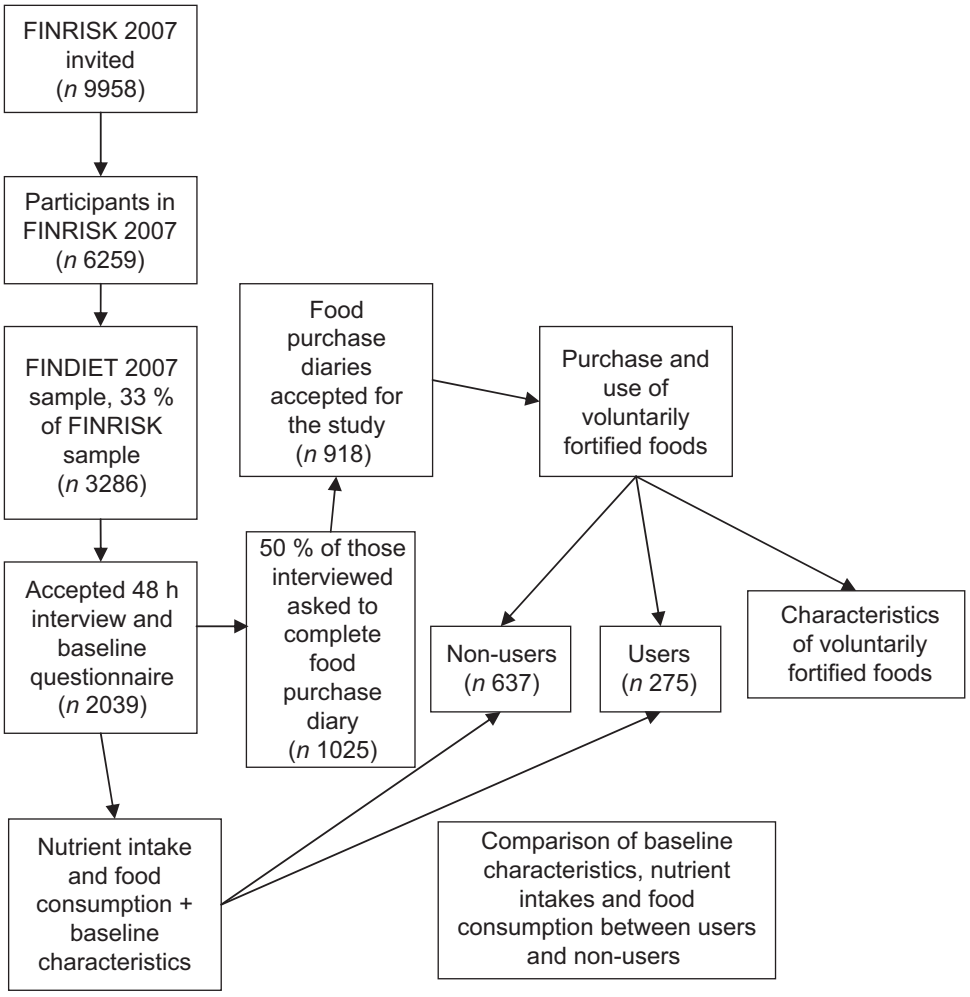

Fig. 1 Flowchart of the study

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The participation rate was 63 %; i.e. 6259 subjects participated. Of these, 2069 persons were invited to participate in the FINDIET Survey[5].

The participants were interviewed with a 48 h dietary recall instrument between January and March 2007. Details of the method have been reported previously[5]. In short, all foods, beverages and food supplements consumed by the participant over the two previous days were recorded and portion sizes were estimated from a food photograph booklet and household measures. Pictures of the most commonly used food supplements were also available to aid in identification of the correct product. The 48 h recall data covered all days except Fridays. The National Food Composition Database Fineli® (www.fineli.fi), which also includes data on food supplements, was used to calculate the food consumption and nutrient intake values.

Additionally, a sub-sample (50 %) of the participants in the FINDIET Survey was asked to fill in a 5-d barcode-based product purchase diary (or 'product diary') to assess the purchase and use of food products. The participants were instructed to record all food purchased for home consumption by any member of the household or by the participant for his/her outside-the-home consumption (snack bars, sweets, etc.) for five consecutive days. Restaurant, cafeteria and fast-food meals and drinks were not recorded. If no food was purchased on one or more days, the respective pages were to be left empty. The participants were asked to write a detailed description of each food item, including the type of food, brand name, name of the product and manufacturer. Also, the purchase date, the number of packages, the weight of one package, and the last four digits of the barcode (if available) were filled in. Foods with no barcode, such as loose fruit and vegetables, were recorded as well. Finally, the participants were asked to tick boxes for a food in the product diary if the product was intended for use (as-is or as an ingredient): (i) by the participant him-/herself or (ii) by a household member under 7 years of age. In the present study, the participant's own use of any of the voluntarily fortified foods purchased was used as the criterion for the participant's classification as a user as opposed to a non-user.

In all, 930 participants (91 %) returned product diaries, of which 918 (90 %) were of acceptable quality (most of the products of the individual diary could be identified). We used a specially designed software and database system for the data entry. Since we did not have direct access to the manufacturers' product registers, we could not directly link the barcodes with the correct product. Instead, the four-digit barcode database was created during the product diary data entry process. If a food item's description was incomplete, we used the barcode to check the item against the information already accumulated in our database. In some cases, we used manufacturers' product catalogues available either in print or online. The four-digit barcode was in most cases sufficient for food identification. Each food item was assigned a food identifier from the Fineli database, enabling data classification according to food group.

The background characteristics of the participants were assessed via questionnaires and measurements in the FINRISK 2007 Study[6]. Alcohol consumption was self-reported as the number of units of different types of alcohol consumed in the previous 7 d. One unit equalled, for example, 300 ml (33 cl) of beer, 120 ml (12 cl) of wine or 40 ml (4 cl) of spirits. Physical activity was self-reported as instances of leisure-time physical activity (minimum of 20 min) per week. The weights of all foods recorded in the product purchase diaries were summed by food group. The voluntarily fortified foods were identified by either: (i) checking the fortification status of the food products mentioned in the general regulation on the Internet or examining the product label; or (ii) using the information obtained from special fortification permissions granted by the Finnish Food Safety Authority for individual food products.

Logistic regression analysis was used to identify the determinants of the use of voluntarily fortified foods. We constructed three models: (i) a univariate model, considering one independent variable at a time; (ii) a saturated model, with all independent variables; and (iii) a third model, with all variables that were found to be statistically significant with the first model. The differences in food consumption and nutrient intakes between users and non-users of voluntarily fortified foods were tested via the unpaired *t* test, and the consumption and intake figures were transformed logarithmically where this was appropriate. In addition, we chose the four nutrients that predominate in voluntary fortification (vitamin D, vitamin C, pyridoxine, Ca) and compared total intake of these nutrients from ordinary foods and food supplements between users and non-users of the foods fortified with the respective nutrient. The calculation omitted the amounts from voluntary fortification in order to determine whether the non-users would have had a lower intake than the non-users if all food had been non-fortified – i.e. whether the users were improving their intake by choosing fortified foods.

Results

Of all food purchased, 2·6 % by mass was voluntarily fortified (Table 1). The fortified food group purchased in the largest amounts (measured in kg) was yoghurts, followed by juice drinks and ready-to-eat breakfast cereals (Table 1). The most commonly used foods by fortification nutrient were those with vitamins D and C. The association of background characteristics with use of fortified foods is presented in Table 2. In logistic regression, sex, age, BMI, children in the household, smoking, alcohol consumption and consumption of vegetables showed a

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Table 1 The total amount of voluntarily fortified food purchased, by food group and added nutrient, among random subgroup of 918 adult participants (aged 25–64 years) in the National FINDIET 2007 Survey

	Yoghurts		Juice drinks		Ready-to-eat breakfast cereals		Energy and wellness drinks		Fruit juices		Quarks		Other fortified foods		All	
	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%
Vitamin D	199	95	0	0	0	0	0	0	0	0	0	0	26	45	225	47
Vitamin C	0	0	174	100	4	34	3	22	7	100	0	0	27	45	217	45
Ca	33	16	8	5	9	67	1	7	6	86	5	100	24	41	84	18
Pyridoxine	0	0	58	33	11	83	11	78	0	0	0	0	8	14	88	18
Niacin	0	0	57	33	13	97	11	78	0	0	0	0	1	2	82	17
Folic acid	0	0	49	28	13	97	0	0	0	0	0	0	6	11	68	14
Vitamin B_{12}	6	3	28	16	13	97	11	78	0	0	0	0	5	9	63	13
Vitamin E	0	0	48	27	5	37	1	7	1	14	0	0	1	2	55	12
Thiamin	0	0	28	16	13	97	0	0	0	0	0	0	3	5	43	9
Vitamin A	0	0	25	14	0	0	1	7	1	14	0	0	0	0	27	6
Products with any voluntary fortification, total	210	100	174	100	13	100	14	100	7	100	5	100	58	100	480	100
Non-fortified products, total		47		141		205		0		415		57		–*	17 836	100

*Not calculated.

link with the use of fortified foods in univariate models (Table 3). However, when all statistically significant variables were incorporated into the same model, only the consumption of fruits and vegetables and age were independently associated with use. Those who showed high consumption of fruits and vegetables were more likely to use fortified foods than others were. In addition, younger participants were more likely to use fortified foods than were older ones.

The food consumption and nutrient intakes (excluding intake from voluntarily fortified foods) of users and non-users of fortified foods are compared in Tables 4 and 5. Consumption of fruits and vegetables, yoghurts, ready-to-eat breakfast cereals (for women only), and juice drinks was higher among users of fortified foods than among non-users (Table 4). Also, among men, consumption of cooked potatoes was lower among users than among non-users. In nutrient intake, the sucrose intake among men was significantly higher and the proportion of fat of total energy intake was significantly lower among users than among non-users. Vitamin C intake from ordinary foods and the sum of intake from ordinary foods and food supplements were higher among those who consumed foods fortified with vitamin C (Table 5). There were no statistically significant differences between users of foods fortified with vitamin D, pyridoxine or Ca and non-users in respective nutrient intake from ordinary foods and/or from food supplements.

Discussion

Our study shows that the users of voluntarily fortified foods had a higher consumption of fruits and vegetables and were younger than non-users. No other background characteristic was found to be associated with use when we controlled for other background characteristics. Furthermore, users of voluntarily fortified foods did not show lower intakes of the nutrients that were used to fortify the products they purchased. In fact, users of vitamin-C-fortified products had a higher intake of vitamin C from ordinary foods; therefore, use of fortified foods increased rather than decreased the difference in vitamin C intake between users and non-users.

Yoghurt and juice drinks were the most frequently used voluntarily fortified foods. This is probably because these foods (fortified or not) are, in general, used by a large proportion of the population in Finland (25–64-year-olds): 32 % of men and 49 % of women ate yoghurt, and 35 % of men and 27 % of women drank sugar-sweetened fruit drinks during the 48 h recall period[7]. In addition, a large proportion of yoghurts and juice drinks are fortified. Therefore, the use of voluntarily fortified foods may not always be a conscious choice so much as a result of the fact that non-fortified options are few or not available at all in the store. The choice of a fortified product may also

Table 2 Background characteristics of users and non-users of voluntarily fortified foods: random subgroup of 918 adult participants (aged 25–64 years) in the National FINDIET 2007 Survey

	Men				Women			
	Non-users		Users		Non-users		Users	
Background characteristic	*n*	%	*n*	%	*n*	%	*n*	%
Age (years)								
25–34	33	11	16	15	44	14	30	18
35–44	54	18	20	19	54	17	43	26
45–54	55	18	27	25	61	19	41	25
55–64	80	26	25	22	64	21	34	20
65–74	83	27	20	19	92	29	19	11
BMI (kg/m^2)								
<18·5	1	0	0	0	1	0	3	2
18·5–24·9	93	31	42	39	122	39	75	45
25·0–29·9	140	46	46	43	111	35	59	35
≥30·0	71	23	20	18	81	26	30	18
Education level								
Lowest	110	36	28	26	88	28	40	24
Middle	99	33	43	40	112	36	60	35
Highest	96	31	37	34	114	36	66	40
Marital status								
Married	216	71	83	77	231	73	120	72
Unmarried, divorced or widowed	89	29	24	22	84	27	47	28
Children younger than 16 years in the household								
No	216	71	71	65	212	67	98	59
Yes	69	22	33	31	87	28	64	38
Smoking								
Daily	78	26	15	14	37	12	19	11
Irregular smoker	16	5	11	10	19	6	14	8
Non-smoker	211	69	82	76	259	82	134	81
Units of alcohol per week								
0	63	21	24	22	86	27	37	22
1–3	60	20	25	23	83	26	53	32
4–7	53	16	23	21	49	16	41	25
≥8	93	31	26	24	43	14	15	9
Physical activity (sessions/week)								
≤1	106	35	31	29	86	27	47	28
2–3	101	33	40	36	119	38	71	42
≥4	71	23	33	31	89	28	43	26
Physically handicapped	15	5	4	4	10	3	3	2
Total	305	74	108	26	315	65	167	35

be based on attributes other than fortification, such as taste, familiarity, convenience and price[8]. Ready-to-eat breakfast cereals are the most commonly used voluntarily fortified foods worldwide[9–12]. In Ireland[12], these have somewhat the same role yoghurts and juice drinks do in Finland: they are widely used and are most often fortified. Therefore, it seems that in many countries the use of voluntarily fortified foods is not always a very conscious choice and is a consequence of a supply dominated by fortified products.

Our study is in line with an Irish study[13] in which younger persons used fortified foods more often than older ones. In the Irish study, also higher education was associated with use, while in our study education was not an independent determinant of use. In addition, our study did not find use of fortified foods to be associated with other behaviour than food-related ones. It is surprising that a higher education was not associated with the use of fortified foods, although consumption of fruits and vegetables is associated directly with both education[14] and the use of fortified foods. In the univariate model, education level showed a significant association with the use of fortified foods, but this association weakened to non-significance when other background factors were controlled for. It cannot be ruled out that in a larger study population education level could have been shown to be a significant determinant. However, if the choice of a fortified food product over a non-fortified one is predominantly not conscious, the background characteristics of users are bound to be similar to those of non-users.

In our study, differences in nutrient intakes and in food consumption were modest. This is not in line with the Irish study[13], where energy, protein, carbohydrate and sugar intakes were higher among greater users of fortified foods. The only difference in nutrient intake between users and non-users in the present study was in sucrose intake. The higher sugar intake among users could indicate that fortification has improved nutritional quality in the eyes of consumers. However, there was no significant difference in energy intake. Also in the UK, fortified foods

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Table 3 Logistic regression analysis of the association between voluntarily fortified foods use (yes/no) and background factors, presented as odds ratios with 95 % confidence intervals: random subgroup of 918 adult participants (aged 25–64 years) in the National FINDIET 2007 Survey

		Model 1*			Model 2†			Model 3‡		
Background factor	*n*	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value
Sex										
Men	413	1·00	Ref.		1·00	Ref.				
Women	482	1·50	1·12, 2·00	0·006	1·10	0·80, 1·52	0·56			
Age (years)										
25–34	123	1·00	Ref.		1·00	Ref.		1·00	Ref.	
35–44	171	0·97	0·60, 1·57	0·92	0·92	0·54, 1·54	0·74	0·91	0·54, 1·52	0·71
45–54	184	0·98	0·61, 1·57	0·94	0·98	0·59, 1·63	0·94	0·99	0·60, 1·64	0·98
55–64	203	0·68	0·43, 1·10	0·12	0·72	0·42, 1·24	0·24	0·72	0·42, 1·24	0·24
65–74	214	0·37	0·22, 0·62	<0·001	0·41	0·23, 0·73	0·002	0·40	0·23, 0·71	<0·001
BMI (kg/m^2)										
18·5–24·9	332	1·00	Ref.		1·00	Ref.				
25·0–29·9	356	0·77	0·56, 1·06	0·11	0·90	0·64, 1·28	0·57			
≥30·0	202	0·60	0·41, 0·89	0·01	0·69	0·45, 1·06	0·93			
Age-adjusted education level										
Lowest	266	1·00	Ref.		1·00	Ref.				
Middle	314	1·42	0·99, 2·04	0·06	1·32	0·90, 1·94	0·15			
Highest	313	1·43	0·99, 2·05	0·05	1·18	0·80, 1·75	0·41			
Marital status										
Married or cohabitation	650	1·00	Ref.		1·00	Ref.				
Single, divorced or widowed	244	0·90	0·66, 1·25	0·54	0·99	0·69, 1·42	0·95			
Household with children less than 16 years old										
No	597	1·00	Ref.		1·00	Ref.				
Yes	253	1·58	1·16, 2·15	<0·001	1·12	0·74, 1·68	0·6			
Smoking										
Daily	149	1·00	Ref.		1·00	Ref.				
Occasionally	60	2·45	1·27, 4·58	0·01	1·46	0·73, 2·92	0·28			
Non-smoker	686	1·55	1·03, 2·35	0·04	1·21	0·76, 1·92	0·42			
Consumption of alcoholic drinks (units/week)										
0	210	1·00	Ref.		1·00	Ref.				
1–3	221	1·33	0·89, 2·00	0·17	1·14	0·74, 1·75	0·55			
4–7	166	1·53	1·00, 2·36	0·5	1·28	0·81, 2·02	0·29			
≥8	177	0·74	0·47, 1·17	0·19	0·68	0·41, 1·12	0·13			
Consumption of fruits and vegetables daily (g)										
≤100·0	228	1·00	Ref.		1·00	Ref.		1·00	Ref.	
100·1–220·0	221	1·77	1·15, 2·73	0·01	1·63	1·03, 2·58	0·04	1·63	1·04, 2·57	0·04
220·1–356·9	222	1·91	1·24, 2·94	0·01	1·77	1·11, 2·83	0·02	1·92	1·22, 3·04	0·02
≥356·91	224	2·83	1·86, 4·32	<0·001	2·54	1·59, 4·06	<0·001	2·72	1·73, 4·28	<0·001
Physical activity (sessions/week)										
≤1	270	1·00	Ref.		1·00	Ref.				
2–3	331	1·24	0·88, 1·76	0·22	1·12	0·77, 1·63	0·55			
≥4	236	1·17	0·80, 1·71	0·42	1·1	0·72, 1·66	0·66			
Physically handicapped	32	0·69	0·29, 1·66	0·41	0·83	0·33, 2·09	0·7			
Use of food supplements										
No	507	1·00	Ref.		1·00	Ref.				
Yes	388	1·13	0·85, 1·50	0·4	0·99	0·73, 1·34	0·94			

Ref., referent category.
*Univariate model: only one variable at a time in the model.
†Saturated model: all variables addressed at the same time in the model.
‡Final model: only variables that are statistically significant covered at the same time in the model.

often are of low nutritional quality: in a study carried out in the UK in 2003, 260 fortified food products were identified and 75 % of these had a high content of sugar, fat or salt[1].

The differences in food consumption, except for fruits and vegetables, were also small and were mainly found in those food groups that were also fortified. This increases the confidence in our main method (the product diary), which was independent of the method used to estimate food consumption.

Why was the consumption of fruits and vegetables the only background factor, apart from age, associated with use of voluntarily fortified foods? It is possible that high consumption of fruits and vegetables is a sign of food-related health-consciousness and that persons who are health-conscious in relation to food are not necessarily so in other areas of health behaviour (e.g. smoking or physical activity). In fact, an American study[15] found that health-related behaviours are not related to each other. However, in another study, poor food choices were

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Table 4 Consumption of selected foods (g/d) and daily intake of selected nutrients among users and non-users of voluntarily fortified foods: random subgroup of 918 adult participants (aged 25–64 years) in the National FINDIET 2007 Survey

	Men					Women				
	Users		Non-users			Users		Non-users		
	Mean	95 % CI	Mean	95 % CI	*P* value	Mean	95 % CI	Mean	95 % CI	*P* value
Fruits and vegetables*	274	220, 328	195	174, 216	<0·001	325	269, 354	271	248, 294	<0·001
Cooked potatoes	61	47, 75	84	74, 94	0·02	46	37, 54	51	45, 57	0·18
Porridges	114	82, 146	109	90, 128	0·92	85	68, 102	93	81, 105	0·27
Rye bread	104	88, 119	107	97, 117	0·98	72	63, 81	69	63, 75	0·76
Ready-to-eat breakfast cereals	5	3, 7	5	3, 7	0·28	7	4, 9	4	2, 5	<0·001
Skimmed milk	164	101, 226	119	91, 148	0·36	128	98, 158	113	92, 134	0·08
Yoghurts	73	46, 101	42	32, 53	0·01	96	81, 111	46	37, 55	
Hard cheese	31	22, 41	23	19, 27	0·9	23	18, 29	18	16, 21	0·14
Margarine and vegetable fat	22	16, 27	20	17, 22	0·9	12	10, 14	12	10, 14	0·4
Fish and seafood	49	32, 66	49	39, 58	0·95	39	27, 51	48	40, 55	0·09
Meats and meat-based foods	168	136, 200	141	127, 156	0·27	108	92, 123	104	91, 116	0·43
Sausages and cold cuts	49	37, 61	60	52, 67	0·05	20	20, 30	23	19, 26	0·06
Sweets	24	16, 31	19	16, 22	0·65	17	13, 22	17	14, 20	0·62
Juice drinks	144	101, 188	116	90, 143	0·04	78	57, 99	58	42, 73	0·02
Coffee	487	418, 556	563	515, 612	0·17	417	373, 461	413	367, 449	0·43
Alcoholic drinks	174	102, 246	166	108, 223	0·13	41	24, 57	53	34, 72	0·63
Intake of										
Protein (%E)	17	16, 17	17	16, 17	0·74	17	17, 18	17	17, 18	0·77
Carbohydrates (%E)	49	47, 51	48	47, 49	0·27	51	50, 52	50	49, 51	0·32
Sucrose (%E)	11	10, 12	10	9, 10	0·02	10	10, 11	10	10, 11	0·44
Fat (%E)	32	30, 33	33	32, 34	0·02	30	29, 31	31	30, 32	0·22
Saturated fat (%E)	12	11, 13	13	13, 14	0·24	12	11, 12	12	12, 13	0·1

%E, percentage of energy intake.
*Does not include fruit juices.

shown to be related to smoking and high alcohol consumption[16]. Also, in a German study among elderly people[17], a healthy diet was associated with regular exercise and with not smoking. Therefore, it is possible that the independence of food-related health-consciousness is just a chance finding or is due to the small number of participants in the present study.

From a public health perspective, targeting for the use of voluntarily fortified foods does not seem to be successful: the intake of several nutrients among users of fortified foods was at the same level or even higher among non-users. Fortified foods were not used by those whose intake from other sources was low. However, from a food safety viewpoint, we found no significant accumulation of risk of excessive nutrient intake from fortified foods and other sources. The risk of exceeding the upper intake limit for vitamins and minerals seems small, because, on one hand, the proportion of voluntarily fortified foods among all foods purchased was small (2·6 %) and, on the other hand, among users of fortified foods, nutrient intake from other sources (ordinary foods and food supplements) was not higher than that of non-users. Therefore, high intake from fortified foods and from other sources does not accumulate in the same people.

The barcode-based purchase diary proved to be suitable in assessing the use of voluntarily fortified foods, and the last four digits of barcodes were shown to be sufficient for product identification. The method was not too great a burden for participants, as 89 % returned an acceptable diary. We also found that the barcode was very useful both in ascertaining that the product description was right and in expediting data entry. Its drawback is that, since it addresses only the intention to use a product, the portion sizes actually consumed cannot be determined and therefore actual nutrient intake figures cannot be calculated. In addition, the method does not take account of food that is not eaten (waste food). One alternative would have been to identify the consumption of voluntarily fortified products in the 48 h recall. However, it is likely that not all voluntarily fortified foods were identified in the product diary either, because information on fortification was not available for some foods. However, this problem applied to only a small proportion of foods. In addition, it must be borne in mind that the method was new and non-validated and that, therefore, the results of the present study should be taken with caution. Furthermore, it is not known whether the method affected shopping behaviour during the recording period, so, again, the results should be interpreted with caution.

In a previous Finnish study, consumption of fortified foods was addressed in an Internet–based survey[11]. However, that study proceeded from the assumption that participants are able to distinguish fortified foods from ordinary foods. We do not think that participants are always able to draw the line between fortified and non-fortified foods. Also, addition of phytosterols or other bioactive substances to foods may be regarded as food fortification by participants. In summary, despite its

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Table 5 Daily intakes of nutrients from natural sources and from food supplements among users and non-users of foods that are voluntarily fortified with the respective nutrient: random subgroup of 918 adult participants (aged 25–64 years) in the National FINDIET 2007 Survey

	Non-users				Users					
	n	Mean	95 % CI	Median	*n*	Mean	95 % CI	Median	*P* value	Recommendation*, men/women
Vitamin D from food (µg)	731	6·8	6·4, 7·2	5·2	164	6·0	5·3, 6·8	4·5	0·17	7·5/7·5
Vitamin D from food supplements (µg)	731	2·2	1·8, 2·5	0·0	164	2·0	1·5, 2·6	0·0	0·39	
Total vitamin D intake (µg)	731	8·9	8·4, 9·5	6·9	164	8·1	7·2, 8·9	6·7	0·38	
Vitamin C from food (mg)	775	107	101, 112	87	120	121	107, 136	105	0·00	75/75
Vitamin C from food supplements (mg)	775	57	44, 70	0	120	68	40, 96	0	0·19	
Total vitamin C intake (mg)	775	163	149, 177	111	120	190	160, 219	135	<0·001	
Pyridoxine from food (mg)	837	1·8	1·8, 1·9	1·7	58	1·8	1·7, 2·0	1·7	0·74	1·6/1·2
Pyridoxine from food supplements (mg)	837	3·2	1·7, 4·7	0·0	58	1·9	0·7, 3·2	0·0	0·57	
Total pyridoxine intake (mg)	837	5·1	3·6, 6·6	2·0	58	3·7	2·5, 5·0	2·0	0·52	
Ca from food (mg)	815	1086	1048, 1124	980	80	1132	1003, 1261	1023	0·39	800/800
Ca from food supplements (mg)	815	59	47, 72	0	80	67	12, 124	0	0·54	
Total Ca intake (mg)	815	1145	1106, 1184	1055	80	1200	1059, 1339	1039	0·44	

*Nordic Nutrition Recommendations (2004) *Integrating Nutrition and Physical Activity*. Copenhagen: Nordic Council of Ministers.

drawbacks and qualitative nature, we found the new method used, the product purchase diary, to be a useful tool in assessing the use of fortified foods and possibly other behaviour-related food consumption that may be difficult to capture with other methods.

In conclusion, use of voluntarily fortified foods in Finland is rather low and is only weakly associated with other lifestyle factors. Voluntary fortification is not nutritionally well targeted, but neither is it associated with the risk of excessive intake of vitamins and minerals. Therefore, voluntary fortification does not seem to be a good tool to increase vitamin and mineral intake among those whose intake is low. In addition, the barcode-based purchase diary proved to be feasible method for collection of data on use of specific products. The study yields important information for utilisation in nutritional risk assessment for fortified foods.

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