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Intake and sources of α-linolenic acid in Dutch elderly men

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Objective: Intake of α-linolenic acid may have a beneficial effect on coronary heart disease, but little information is available on the intake and sources of α-linolenic acid (C18:3 $n-3$) in populations. We therefore assessed intake and sources of α-linolenic acid in Dutch elderly men.
Design and Subjects: Dietary histories were obtained from participants of the Zutphen Elderly Study, a Dutch cohort study. Food consumption data were available from 876 men in 1985 and from 541 of the same men in 1990. Daily intakes of α-linolenic acid were assessed using a food table developed for this purpose. Alpha-linolenic acid content of edible fats, seafood and some commonly eaten dishes were mainly derived from chemical analyses of Dutch foods, and other values were obtained from published food tables.
Results: Alpha-linolenic acid provided $0.5 \pm 0.1\%$ of energy intake (mean $\pm$ s.d.) or 1.30 ± 0.46 g/day in 1985, and 1.21 ± 0.52 g/day in 1990. The Pearson correlation coefficient for intake of α-linolenic acid in 1985 and 1990 was 0.34. Margarines were the main source (25.4%), followed by meat and the fats used in cooking meat (10.8%), bread (9.8%) and vegetables (7.8%).
Conclusions: An increase in intake of α-linolenic acid, is most easily realized by the use of unhydrogenated oils rich in α-linolenic acid such as rapeseed and soybean oil, and of margarines and other fats containing such oils.
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Descriptors: α-linolenic acid, intake, sources, biomarker, serum cholesteryl esters, fatty acid composition

Introduction

Alpha-linolenic acid (C18:3 $n-3$) is an essential fatty acid. It can be converted in man to the omega-3 long-chain fatty acids eicosapentaenoic acid (EPA, C20:5 $n-3$) and docosahexaenoic acid (DHA, C22:6 $n-3$). These compete with arachidonic acid (C20:4 $n-6$) and may inhibit the production of thromboxane and leukotrienes, promote vasodilatation, and reduce platelet aggregation (Leaf *et al*, 1988). Alpha-linolenic acid may thus reduce the risk of coronary heart disease. Indeed, platelet aggregation was decreased in French farmers with a higher intake of α-linolenic acid (Renaud *et al*, 1986). In a randomized trial an α-linolenic acid-rich 'mediterranean' diet reduced risk of recurrent myocardial infarction, other cardiac events and overall mortality (Lorgeril de *et al*, 1994).

Research on the effects of α-linolenic acid is hampered by the lack of information on intake of α-linolenic acid and levels in foods. We therefore assessed the intake and sources of α-linolenic acid in Dutch elderly men.

Subjects and methods

Study population

The study population consisted of men who participated in the Zutphen Elderly Study (the Dutch contribution to the Seven Countries Study) in 1985. In 1960, 1088 men from Zutphen, born between 1900 and 1919 were invited to take part in a longitudinal study, and 872 men took part in the medical and food consumption examination. In 1985, 555 of the participants were still alive and 367 of them were re-examined. At the same time 711 other men of the same age group from Zutphen were asked to participate. A total of 939 men was examined, and food consumption data were available from 876 men. In 1990, 718 of these 939 men were still alive, and 560 took part in a follow-up examination, a dietary history was available for 541 men.

In 1985 a subcohort of the Dutch cohort was formed in which the fatty acid composition of serum cholesteryl esters was determined as a possible biomarker for intake of fatty acids. The fatty acid composition of serum cholesteryl esters from non-fasting blood samples was determined by gas chromatography on packed columns, as described (Sandker *et al*, 1992). This Dutch subcohort consisted of 100 survivors of the cohort of 1960, who were randomly selected and matched for age with the Crete-cohort consisting of 100 men (Sandker *et al*, 1992). Therefore the subcohort differed in age from the total cohort. A Student's *t*-test showed that they did not differ significantly in intake of energy, total fat, linoleic acid and α-linolenic acid. Only the data on the fatty acid composition of the cholesterylesters of the Dutch subcohort were used in the present study.

Dietary survey

Food consumption data were collected between March and June in 1985 and again in 1990 by means of the cross-check dietary-history method (Burke, 1947) adapted to the Dutch

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situation (Bloemberg *et al*, 1989). This method provides information about the usual food consumption pattern during the two to four weeks preceding the interview. The participants were interviewed, together with the person who prepared the meals, about their usual food consumption pattern. The results were checked by estimating the average consumption of foods during a day or a week and the quantities of food purchased for the family during a week. From this information the usual food consumption during an average weekday was calculated.

A food table was constructed with data on the amount of α-linolenic acid in approximately 1000 products that were consumed by the participants of the Zutphen Elderly Study. We used data of chemical analysis, food tables, deduction from other values and calculations based on recipes (Voskuil *et al*, 1994). Chemical analyses were available for 132 foods, including some commonly used foods in the Netherlands, as well as most edible fats and seafood (Nederlands voedingsmiddelenbestand, 1993; Hulshof *et al*, 1990; Hulshof *et al*, 1991). For 287 foods α-linolenic acid content was derived from foreign food tables (Rastas *et al*, 1989; Livsmedelstabeller, 1986; Paul *et al*, 1980; Watt and Murill, 1963; Renaud *et al*, 1989). One hundred and thirty foods did not contain any fat nor α-linolenic acid. The content of the remaining foods was deduced from other foods. Other nutrient intake data are based on the Dutch food table (Nederlands voedingsmiddelenbestand, 1993).

Statistics

Statistical analyses were carried out using SAS (SAS Institute Inc., 1987). Vâriables that were not normally distributed were transformed to their natural logarithm. Pearsons correlation coefficients were used to study associations. R-values of 0.09 and 0.12 are significant at the 0.05 and 0.01 level respectively for associations between dietary intakes ($n > 500$). For associations between intake and fatty acid composition of the serum cholesteryl esters ($n = 100$) *r*-values of 0.20 and 0.25 are significant at the 0.05 and 0.01 level respectively.

Results

Intake of α-linolenic acid

The average age of the participants was 71.5 ± 5.3 y in 1985 and 75.1 ± 4.6 y in 1990. Energy intake and intake of fat decreased from 1985–1990, but intake of linoleic acid increased slightly (Table 1). The average daily intake of α-linolenic acid was 1.30 ± 0.46 g/day in 1985 and 1.21 ± 0.52 g/day in 1990. In both 1985 and 1990 this was equal to 0.5 percent of energy intake. The correlation between intake of α-linolenic acid in 1985 and 1990 was 0.34. For linoleic acid this was 0.47. Figure 1 shows the distribution of daily intake of α-linolenic acid of the participants. The median intake was lower than the mean; it was 1.24 g/day in 1985 and 1.11 g/day in 1990.

Table 1 Intake of α-linolenic acid and other nutrients (mean ± s.d.) by the participants of the Zutphen Elderly Study in 1985 and 1990

	1985 ($n = 876$)	*1990* ($n = 541$)
Energy (MJ/day)	9.5 ± 2.2	8.8 ± 1.9
Total fat (g/day)	100.2 ± 31.1	93.5 ± 29.4
Linoleic acid (g/day)	13.8 ± 7.9	15.2 ± 8.7
(en%)	5.5 ± 2.9	6.6 ± 3.3
α-linolenic acid (g/day)	1.3 ± 0.5	1.2 ± 0.5
(en%)	0.5 ± 0.1	0.5 ± 0.2

The intake of α-linolenic acid was strongly associated with intake of total fat ($r = 0.71$ and $r = 0.63$, in 1985 and 1990, respectively) and mono-unsaturated fatty acids ($r = 0.74$ and $r = 0.63$, respectively). The correlation was 0.57 in 1985 and 0.47 in 1990 for saturated fatty acids, and 0.43 and 0.34, respectively, for poly-unsaturated fatty acids ($P < 0.001$).

The food group margarine (including low-fat margarines) provided the largest contribution to the intake of α-linolenic acid, 25.4% of total intake (Table 2). In 1991, the year in which margarine samples were analyzed, margarines in the Netherlands contained 1.5–2.5 g α-linolenic acid per 100 g, and low-fat margarines contained 1.5–2.0 g per 100 g (Hulshof *et al*, 1990). The 'diet' varieties (namely high poly-unsaturated) of margarine contained only 0.1–0.2 g α-linolenic acid per 100 g product. A substantial contribution to the intake was also provided by (prepared) meat (10.8%), bread (9.8%) and vegetables (7.8%) (Figure 2). The contribution of meat was due to frying fats used for cooking as well as to the α-linolenic acid content of the meat itself. Although the fat content of vegetables is low, leafy vegetables (especially purslane), bean sprouts, and some cruciferous vegetables (for example kale, green cabbage) contain relatively large amounts of α-linolenic acid (0.1–0.4 g/100 g) (Table 2), some 25–50% of the total amount of fat in those vegetables. Margarine, meat, bread and vegetables together contributed over 50% to the total intake of α-linolenic acid.

Fatty acid composition of cholesteryl esters as biomarker for intake of α-linolenic acid

The average content of α-linolenic acid in cholesteryl esters was 0.32% of the total amount of fatty acids. Our method failed to detect α-linolenic acid in one fourth of the participants. The cholesteryl ester fatty acids consisted for 52.74% of linoleic acid and for 4.42% of arachidonic acid.

Table 2 Mean contribution of various food groups to the intake of α-linolenic acid in the Zutphen Elderly Study

Food group source	*% of intake*	*Fat* g/100 g	18:3 g/100 g
Margarine	25.4		
margarine		83.00	2.08
diet margarine		82.80	0.22
low fat margarine		40.00	1.84
low fat diet margarine		40.00	0.08
Meat	10.8		
beef, 15–24 g fat, unprepared		20.00	0.34
pork, > 19 g fat, prepared		28.60	0.32
processed meat, average		27.78	0.28
Bread	9.8		
bread, wheat		3.53	0.11
Vegetables	7.8		
spinach, boiled		0.26	0.08
purslane, boiled		0.85	0.40
cabbage, white, boiled		0.25	0.06
Butter	5.8		
butter		82.50	0.57
Cookies and snacks	5.4		
Cheese	4.6		
Shortening	4.0		
Potatoes	4.0		
Milk(products)	3.8		
Fish	3.6		
Sauces	3.5		
Fruit	2.8		
Others	8.7		

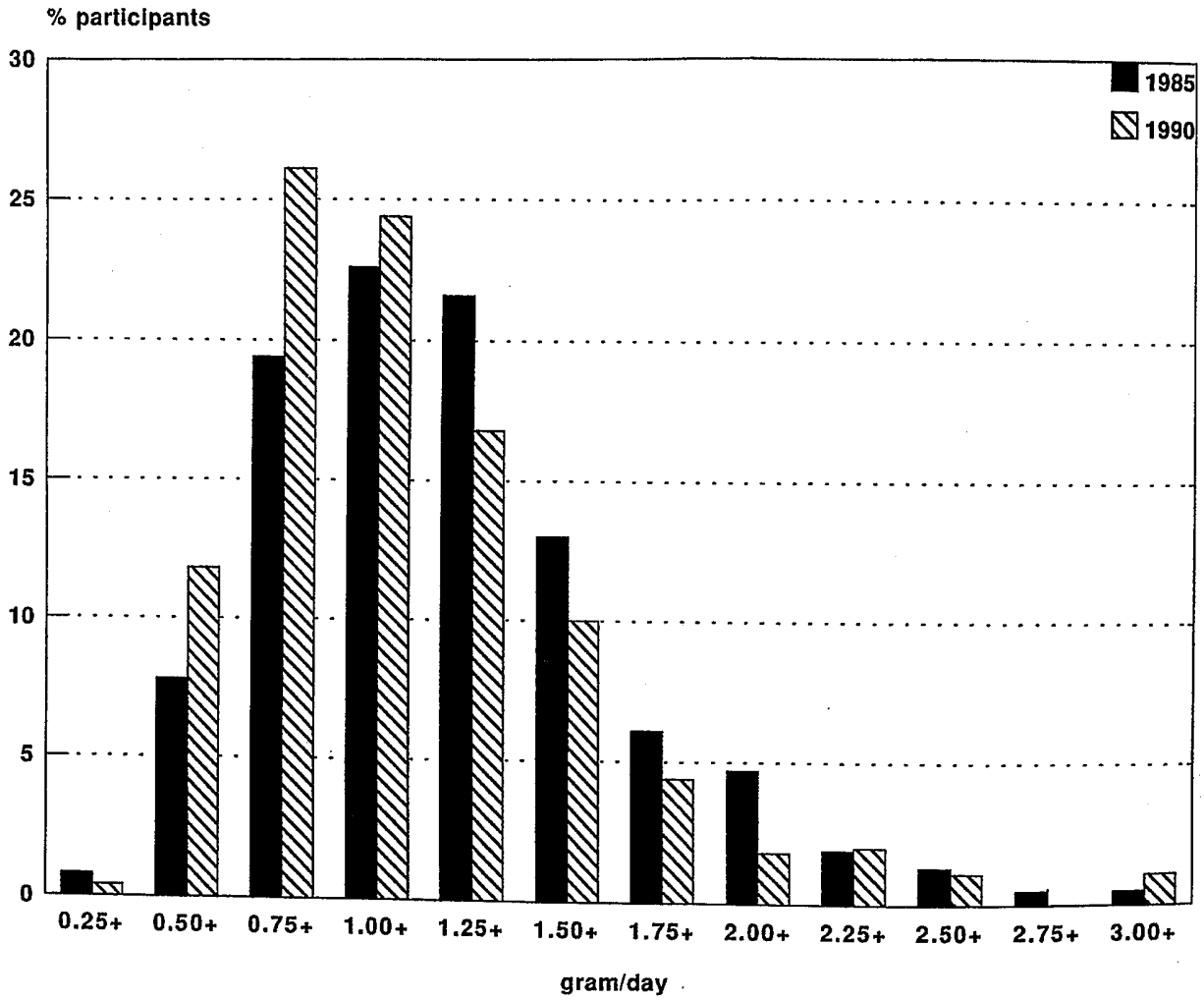

Figure 1 Daily intake of α-linolenic acid in 1985 ($n=876$) and 1990 ($n=541$) in elderly men in the Zutphen Elderly Study.

Intake of α-linolenic acid was not correlated with either α-linolenic acid ($r=-0.14$), linoleic acid ($r=0.14$) or arachidonic acid ($r=-0.12$) in cholesteryl esters. For linoleic acid, the usual strong, positive relation was seen between intake and amount in cholesteryl esters ($r=0.55$, $P<0.01$).

Discussion

The average daily intake of α-linolenic acid amounted to 1.3 g/day in 1985 and 1.2 g/day in 1990 in this cohort of elderly men. This represented an intake of 0.5% of energy intake in both years. In the few studies which refer to the intake of α-linolenic acid, it is assumed that the average intake of α-linolenic acid is about 0.3% of energy intake (Kelley *et al*, 1993; Bjerve *et al*, 1992). Renaud *et al* found, by means of a 24 h recall, that the diet of the controls in their trial consisted of 0.34 energy% α-linolenic acid (Renaud *et al*, 1986). The average daily intake of α-linolenic acid in our study was somewhat higher. Part of this difference could be due to the food table used. When we calculated the intake of linoleic acid using the official Dutch food table (Nederlands voedingsmiddelenbestand, 1993) the average daily intake was about 1 g/day or 5–10% lower. If this would apply to α-linolenic acid as well, it would provide an overestimation, by our own data, of about 0.1 g/day.

In some leafy vegetables a substantial proportion of the fatty acids is α-linolenic acid. However, because their total

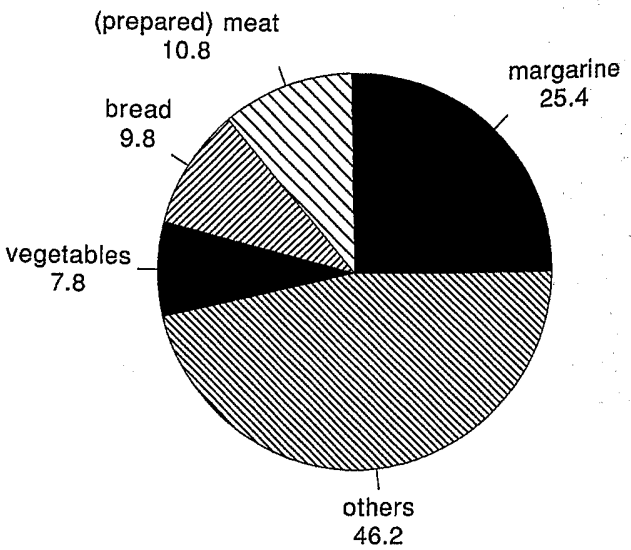

Figure 2 The relative contribution of various food groups to the intake of α-linolenic acid in 1985 and 1990 in the Zutphen Elderly Study.

lipid content is usually less than 1%, the absolute amount of α-linolenic acid is small (Nettleton, 1991). Products like linseed oil, rapeseed oil, soybean oil and walnut oil contain considerable amounts of α-linolenic acid (53, 11, 5 and 7 g/100 g, respectively) (Nettleton, 1991). The question on which foods in the usual diet contribute substantially to the

daily intake of α-linolenic acid has to our knowledge not been addressed previously. In our study margarines made the largest contribution, one fifth of the total intake. Although the fat content of vegetables is very low the contribution from vegetables is still relatively large (8%).

The use of more (partially hydrogenated) vegetables oils instead of highly saturated animal and vegetable fats in manufacturing margarines has increased the contribution of poly-unsaturated fatty acids to the total fat intake. By using specific vegetable oils not only rich in linoleic acid but also in α-linolenic acid like rapeseed (canola) and soybean oil, intake of α-linolenic acid could be further increased. One Canadian margarine for instance consists of only 18% saturated fats, the remainder being a mixture of oleic, linoleic, and α-linolenic acid (Katan, 1994). If a margarine contains 20% rapeseed oil, by weight, the α-linolenic acid content could be 2.2 g/100 g margarine. Replacement of regular margarines by such a margarine could increase α-linolenic acid intake by 0.1–0.6% g/day.

The fatty acid composition of cholesteryl esters is a good indicator for intake of the major fatty acids (Sarkkinen *et al*, 1994). Indeed, we found a correlation of 0.55 between the amount of linoleic acid in cholesteryl esters and in the diet, similar to published values (Glatz *et al*, 1989; Moilanen *et al*, 1983; Moilanen *et al*, 1985). For α-linolenic acid no correlation was found ($r = -0.14$). Some association was expected, although the physiologic relation might be disrupted by competition of other fatty acids, such as arachidonic acid. However, also no correlation with this fatty acid was observed. No information on other fatty acids was available. Possibly the packed column used for analysis for the cholesteryl esters was not suitable for this purpose. Capillary columns provide better resolution and should be used in future studies. A high within-person variation or a low between-person variation in intake or in cholesteryl esters might also be responsible for this low correlation.

In experimental research an increase in α-linolenic acid intake from 0.3% energy to 0.8% energy appeared to lower the risk of a recurrent myocardial infarction (Lorgeril de *et al*, 1994). This was however a secondary prevention trial, and the effects of a small increase in intake of α-linolenic acid in the general population are not yet clear. Potential beneficial effects for the risk of coronary heart diseases could be increased somewhat by more often choosing 'α-linolenic acid rich' vegetables. A more substantial increase in intake can be realized by using margarines that contain relatively large amounts of α-linolenic acid. 'Heart healthy' diet margarines would be healthier if they would contain not only sunflower oil but also unhydrogenated rapeseed and soybean oil.

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