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Aktuelles Thema

On the problematic nature of vitamin E requirements: net vitamin E

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Summary: The requirement for vitamin E is closely related to the dietary intake of polyunsaturated fatty acids (PUFA). By the protective mechanism to prevent PUFA from being peroxidized, vitamin E is metabolically consumed. In addition, PUFA impair the intestinal absorption of vitamin E. Therefore PUFA generate an additional vitamin E requirement on the order of 0.6, 0.9, 1.2, 1.5, and 1.8 mg vitamin E (RRR-alpha-tocopherol-equivalents), respectively, for 1 g of dienoic, trienoic, tetraenoic, pentaenoic, and hexaenoic acid. For this reason, the gross vitamin E content of food containing PUFA does not allow an evaluation of this food as a source of vitamin E. A suitable measure is the net vitamin E content, i.e., gross vitamin E minus the amount needed for PUFA protection. Therefore, some foodstuffs generally considered as vitamin-E sources, as concluded from their gross vitamin E content, cause in reality a vitamin E deficiency if not sufficiently compensated by other vitamin E supplying food constituents. Examples of the net vitamin E content of some fats and oils, fish and nuts are shown. Consequences for food composition data and food labeling and the problem of meeting the vitamin-E requirements are discussed.

Zusammenfassung: Der Vitamin-E-Bedarf steht in engem Zusammenhang mit der alimentären Aufnahme von Polyensäuren. Vitamin E schützt diese Polyensäuren vor Peroxidation und wird dabei selbst verbraucht. Zusätzlich hemmen Polyensäuren die Resorption von Vitamin E. So ist es zu verstehen, daß Polyensäuren einen zusätzlichen Vitamin-E-Bedarf erzeugen, der mit 0,6, 0,9, 1,2, 1,5 und 1,8 mg Vitamin E (RRR-alpha-Tocopherol-Äquivalente) je Gramm Dien-, Trien-, Tetraen-, Pentaen- und Hexaensäure angesetzt werden kann. Deshalb ist der Bruttogehalt an Vitamin E in einem Lebensmittel, welches Polyensäuren enthält, nicht zur Beurteilung dieses Lebensmittels als Vitamin-E-Quelle geeignet. Ein geeigneter Maßstab ist vielmehr der Netto-Vitamin-E-Gehalt nach Abzug der für den Schutz der Polyensäuren benötigten Menge von der Gesamtmenge. Bei Berechnung des Netto-Vitamin-E-Gehalts erweisen sich manche als Vitamin-E-Lieferanten angesehenen Lebensmittel in Wirklichkeit als Erzeuger eines Vitamin-E-Defizits, sofern nicht andere Nahrungsbestandteile kompensatorisch das Defizit ausgleichen. Beispiele für den Netto-Vitamin-E-Gehalt einiger Fette und Öle, Fische und Nüsse verdeutlichen die Problematik. Konsequenzen für Nährstofftabellen und für die Lebensmittelkennzeichnung sowie die Problematik der Deckung des Vitamin-E-Bedarfs werden vor diesem Hintergrund diskutiert.

Key words: net vitamin E, vitamin-E requirements, polyunsaturated fatty acids, food labeling, food composition data

Schlüsselwörter: Netto-Vitamin-E, Vitamin-E-Bedarf, Polyensäuren, Lebensmittelkennzeichnung, Nährstofftabellen

Vitamin E requirements in relation to polyunsaturated fatty acid (PUFA) intake

Recent recognition of the role of aggressive oxygen species in the development of degenerative diseases and on the preventive role of antioxidant vitamins (1) force to reconsider the term "requirement" in connection with those vitamins. Requirements (or daily allowances) have been defined as the level of intake adequate to meet the needs of practically all healthy people. Recommendations are given as constant values depending on age and sex. However, the requirements of antioxidant vitamins are much more variable than those of other vitamins, depending on the extent of oxidant stress a person is exposed to.

PUFA increase the requirement for vitamin E in two ways:
1) PUFA need vitamin E for protection from being peroxidized;
2) PUFA impair the absorption of vitamin E from the gut (2).

For these reasons the vitamin E requirement is closely related to PUFA intake.

The relation between PUFA intake and vitamin E requirement is the subject of a number of studies (see (3) for review). By studying the rate of development of creatinuria, a specific symptom of vitamin E deficiency in rats, Witting and Horwitt estimated the relative quantities of vitamin E required to protect one mole of monoenoic, dienoic, trienoic, tetraenoic, pentaenoic, and hexaenoic acid to approximate to the ratios of 0.3:2:3:4:5:6. Except for monoenic acids, which are less easily oxidized, the vitamin E requirement generated by feeding fatty acids is proportional to the number of double bonds. The absolute amounts of vitamin E needed to compensate for the oxidative stress caused by uptake of 1 g of a given PUFA cannot be defined as accurately. On the basis of data available most experts agree that about 0.6 mg of vitamin E is additionally required for each gram of linoleic acid (3). On the basis of this estimate relative vitamin

Table 1. Vitamin E requirements caused by polyunsaturated fatty acids.

Type of fatty acid	Vitamin E requirement (mg RRR-alpha-tocopherol equivalents per gram fatty acid)
Monoenoic acids	0.09
Dienoic acids	0.6
Trienoic acids	0.9
Tetraenoic acids	1.2
Pentaenoic acids	1.5
Hexaenoic acids	1.8

Table 2. Net vitamin E content of some oils and fats. The vitamin requirement for protection of PUFA is calculated according to Table 1.

Product	PUFA content (g/100 g)		Vitamin E required for PUFA (mg)	Total vitamin E requirement (mg/100 g product)	Gross vitamin E content (mg/100 g)	Net vitamin E content (mg/100 g)
Cotton seed oil	18:2	47.8	28.7	29.6	38.8	+ 9.2
	18:3	1.0	0.9			
Sunflower oil	18:2	60.0	36.0	36.45	55.8	+ 19.35
	18:3	0.5	9.45			
Wheat germ oil	18:2	55.8	33.48	41.49	215.0	+ 174.5
	18:3	8.9	8.01			
Safflower oil	18:2	74.0	33.48	45.21	34.5	− 10.7
	18:3	0.9	0.81			
Lard	18:2	8.6	5.16	8.1	1.6	− 6.5
	18:3	1.0	0.90			
	20:4	1.7	2.04			
Butter	18:2	1.8	1.08	2.16	1.8 – 2.6	− 0.36 – + 0.44
	18:3	1.2	1.08			
Corn oil	18:2	50.0	30.0	30.9	30.9	0
	18:3	1.0	0.9			

Table 3. Net vitamin E content of some fish. For calculation see Table 2.

Product	PUFA content (g/100 g)		Vitamin E required for PUFA (mg)	Total vitamin E requirement (mg/100 g product)	Gross vitamin E content (mg/100 g)	Net vitamin E content (mg/100 g)
Herring	18:2	0.15	0.09			
	18:3	0.062	0.056			
	18:4, 20:4	1.19	1.43	6.56	1.5	– 5.06
	20:5, 22:5	2.78	4.17			
	22:6	0.45	0.81			
Mackerel	18:4	0.16	0.192			
	20:5	0.69	1.035	3.75	1.25	– 2.5
	22:5	0.12	0.18			
	22:6	1.3	2.34			

Table 4. Net vitamin E content of some nuts. For calculation see Table 2.

Nut product	PUFA content (g/100 g)		Vitamin E required for PUFA (mg)	Total vitamin E requirement (mg/100 g product)	Gross vitamin E content (mg/100 g)	Net vitamin E content (mg/100 g)
Cashew	18:2	6.7	4.02	4.16	0.8	− 3.36
	18:3	0.15	0.14			
Peanut	18:2	13.9	8.34	8.86	8.3	0
	18:3	0.53	0.48			
Walnut	18:2	34.1	20.46	27.4	6.2	− 21.2
	18:3	6.8	6.12			
	20:4	0.68	0.82			
Hazelnut	18:2	6.3	3.7	3.83	26.1	+ 22.27
	18:3	0.15	0.13			
Almond	18:2	9.86	5.9	6.13	24.8	+ 18.67
	18:3	0.26	0.23			

E requirements per mole of PUFA with 1 to 6 double bonds can be converted to absolute values as shown in Table 1.

Criteria for the assessment of foodstuffs as sources of vitamin E

Considering the additional vitamin E requirement generated by PUFA intake, it follows that only the net vitamin E content (total vitamin E content minus vitamin E needed for PUFA protection) is relevant for evaluation of vitamin E supply in food containing considerable amounts of PUFA. Food rich in PUFA with low vitamin E content causes a vitamin E deficit that has to be compensated by other food constituents. This is shown in a few examples for fats and oils in Table 2.

Three groups can be distinguished: Oils with high net vitamin E content like cotton seed oil, sunflower oil, and wheat germ oil; fats and oils with a negative vitamin E balance like safflower oil or lard, and fats which are roughly balanced like butter or corn oil. The latter do not generate additional vitamin E requirements, but cannot be regarded as sources of vitamin E. High vitamin E content per se does not justify being labeled as a vitamin-E source, unless the PUFA content is taken into account and the net vitamin E is calculated. Olive oil, for example, is rated fairly high as such; in spite of a moderate gross vitamin E content (about 12 mg/100 g) there remains a net vitamin E content of 5 mg/100 g due to the predominant monoenic acid content with low additional vitamin E requirement. Fish oils, on the other hand, with high PUFA concentrations and low gross vitamin E content cause a vitamin E deficit (Table 3) which is more pronounced with oils than with native fish. Nuts are popularly considered as rich vitamin E suppliers; however, taking the net vitamin E content into account, this cannot be said in general, as shown by the examples in Table 4.

Criteria for food composition data and food labelling

Declarations of vitamin E content in oils and fats or other foodstuffs would be desirable toward appropriate selection of foods that ensure an adequate vitamin E supply. In this context only the net vitamin E content would be meaningful. Unfortunately, there are not enough reliable data available on the net vitamin E content of foodstuffs (RRR-alpha-tocopherol equivalents). In addition, to calculate net vitamin E in a product, not only data on tocopherols are needed, but also on the detailed fatty acid composition. The values in Tables 2–4 are calculated from the food composition and nutrition tables of Souci-Fachmann-Kraut (4). Some of these values do not match those from other nutrition tables. Furthermore, there are large variations due to differences in industrial processing. For other fats (e.g., milk fat) seasonal differences account for pronounced variations in vitamin E content. Reliable data in this area are urgently needed.

The problem of meeting vitamin E requirements

Because of the potential protective action of antioxidative vitamins against various chronic diseases several recent publications suggest that a "prudent diet" should supply a daily intake of 36–60 mg vitamin E, 15 mg β-carotene (or other carotenoids) and 100–150 mg ascorbic acid (5, 6). There are, however, difficulties in realizing these suggestions. Ascorbic acid in these amounts can easily be supplied by normal nutrition. In the case of carotenoids the situation is not quite clear because the bioavailability is more decisive than the amount in food. As to vitamin E, it is questionable whether daily amounts of 36–60 mg can be supplied just by food, without supplementation; all the more so when considering that vitamin-E-rich food like wheat germ oil can only be used in a limited way. Changing to a more vegetarian type of diet, as often recommended, cannot alone solve the problem: approximately 2 kg of red cabbage, 2.5 kg of kale or spinach, or 10 kg of lettuce are necessary to provide 36 mg vitamin E. There is no single type of food that can solve the vitamin E problem as, for example, citrus fruits provide vitamin C. It is instead necessary to combine a variety of foods in order to adequately meet the vitamin E requirements.

This again underscores the need for comprehensive data on the net vitamin E content of a large variety of foodstuffs. The gross vitamin E content without consideration of the PUFA content does not allow an evaluation.

In this regard, recommendations on PUFA uptake (especially fish oils) may have to be reconsidered, since exaggerated PUFA intake without sufficient protection by vitamin E can be harmful. Olive oil, in this respect, can be regarded as useful: it supplies net vitamin E in reasonable amounts, and oleic acid seems to act on plasma lipoproteins as favorably as does linoleic acid (7).

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