Carry over of additional vitamin E amounts from feeds into food of animal origin

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Introduction

Supplementation of high vitamin E levels is very common in animal production in many countries. Vitamin E demand of domestic animals varied between 10 and 20 mg kg^{-1} DM of the feed (GfE 1986, 1987, 1995, 1999). Supplementation of 50 to 100 mg kg^{-1} DM are used in many farms (e.g. BOSSOW, 1995). In some cases higher dosages of vitamin E are added to 1 kg feed under farm conditions. There are many reasons to give high vitamin E levels to domestic animals:

- to improve animal performances,
- to increase animal health,
- to improve the antioxidative state of the animal,
- to improve the quality of food of animal origin,
- to increase the vitamin E content of food of animal origin in order to improve the vitamin E intake of man.

There exist evidence that vitamin E supplementation above the physiological requirements does mostly not improve animal performances as demonstrated in many experiments (e.g. JAKOBSEN et al., 1997, SCHWARZ et al., 1997, SÜNDER et al., 1997a,b, VEMMER et al.,1997).

An increased antioxidative potential in consequence of higher vitamin E intake may improve animal health as measured in improved immunological reactions, decreased mastitis etc. (e.g. HOGAN et al., 1993, MC DOWELL et al., 1996, NOCKELS et al., 1993).

Parameters of quality of foods of animal origin as colour, oxidative stability, tenderness, storage properties etc. may be improved by abundant vitamin E supply as shown by many authors and summarised by ANGELO (1992), FLACHOWSKY et al. (1997b), LEONHARDT et al. (1997), MC DOWELL et al. (1996) recently.

Vitamin E supplementation of feed increased vitamin E content of food of animal origin and may improve vitamin intake of man. This way could be important because of suboptimal vitamin E intake of the population (man: 95%; woman: 84%) compared to the recommendation of the DGE (DGE 1991, 1996). Therefore in some cases vitamin E supplementation of animal feed is recommended to produce better food in order to increase vitamin E supply of human population.

Nothing is known about the carry over of supplemented vitamin E levels from feed into food of animal origin or about the efficiency of such ways to improve vitamin E intake of man. The objective of the present report is to analyse the carry over of additional vitamin E levels into food of animal origin. Mainly data from our research group have been considered in the study.

Materials and methods

Feeding experiments were carried out with dairy cows, bulls, fattening pigs, broilers and layers. Different diets contained various levels of vitamin E or they were supplemented with high vitamin E dosages before slaughtering. More details of experimental design are described by authors mentioned in tables 1 to 4.

Vitamin E determination in feeds and foods of animal origin was done by HPLC as described by MATTEY et al. (1991). Carry over of vitamin E from feed into food was calculated in the following way:

- determination of vitamin E content of edible products of animal origin (milk, meat, fat, eggs, liver etc.),
- determination of weight of edible products of animal origin,
- calculation of vitamin E levels in the edible products (e.p.),
- total carry over = $\frac{\text{vitamin E in e.p.}}{\text{vitamin E intake}} \times 100$
- carry over of vitamin E supplement

$$= \frac{\text{vit. E in e.p. with supplement. - vit. E in e.p. without supplement.}}{\text{supplemented vitamin E amount}} \times 100$$

Results and discussion

Vitamin E content of foods

Vitamin E supplementation increased vitamin E content of foods of animal origin as shown in tables 1 to 4. The lowest effect were observed in dairy milk (Table 1).

Feeding of silage or hay (preservates) effected lower vitamin E content of milk than forage feeding. Oilseeds like rapeseed may increase the vitamin E content of seeds and the better vitamin E absorption together with fats (COHN, 1993, KAYDEN and TRABER, 1993).

Similar responses of abundant vitamin E levels were measured in beef and pork (Table 2). Short term vitamin E supplementation of bulls (1 g per animal per day beginning 21 days before slaughtering) increased tocopherol concentration of muscle from 1.0 to 1.1 mg kg^{-1} (KUHN et al., 1997). Probably the period of vitamin E application was to short for bulls. Longer application (0.6 or 2 g per animal per day for 120 days) increased vitamin E concentration of muscle to >3 mg kg^{-1} (SCHWARZ et al., 1997).

In four experiments with fattening pigs various vitamin E levels were supplemented before slaughtering (Table 2). In the fifth experiments 0, 100 and 200 mg vitamin E were added per kg feed and compared with 1.2 g vitamin E supplementation per day during the last 21 days before slaughtering.

Table 1: Vitamin E content of dairy milk depending on feeding and vitamin E supplementation of cows by various authors

Author	Feeding (roughage), Vitamin E supplementation (g per animal per day)	Vitamin E content of milk	
		mg l^{-1}	µg g^{-1} fat
JAHREIS	Without rapeseed	1.1	25
et al. (1993)	+ 1kg rapeseed per animal per day	1.6	41
NICHOLSON	Corn silage	max. 1.1	max. 28
and	Corn silage (+7 g)	2.0	50
ST. LAURENT (1991)	Alfalfa silage	1.3	max. 32
	Alfalfa silage (+ 3 g)	2.0	50
NICHOLSON	Alfalfa silage	0.6	15
et al. (1991)	Alfalfa silage (+ 3 g)	1.0	26
SCHEIDE	Silage (+ 1 g)	1.3	35
et al. (1995)	Fresh grass (+ 1 g)	1.8	45
ST. LAURENT	Forages (+0.7 g)	0.7	17
et al. (1990)	Forages (+1 g vit. E)	1.0	25

Similar vitamin E intake (~25 g) was achieved of pigs consuming 100 mg vitamin E per kg feed or 1.2 g vitamin E per day during the last 21 days. The results show adequate vitamin E levels in muscle and fat (Table 2, ROSENBAUER et al., 1998). In consequence of those data results after short term vitamin E application seems to be representative and could be considered for carry over calculations.

Broilers showed a higher response of vitamin E supplementation (Table 3) than bulls and pigs. 100 mg vitamin E per kg feed increased vitamin E concentration in thigh muscle from 1.1 to 4.9 and in breast muscle from 2.6 to 7.2 mg kg^{-1}.

Considerable increase of vitamin E content was measured in eggs (Table 4). High dosages of vitamin E to broilers and layers (Tables 3 and 4) were offered to study toxicological effects of the vitamin (SÜNDER et al., 1998).

Table 2: Vitamin E content in selected food from pigs on vitamin E supplementation by various authors

Author	Feeding, Vitamin E supplementation	Vitamin E content (mg kg^{-1}) Liver	Muscle	Backfat
Berk	Control[1)]	3.8	3.9	7.0
et al. (1998)	+ 0.5 g vit. E per day[2)]	5.6	6.2	9.8
	+ 1 g vit. E per day[2)]	7.0	7.8	14.0
Flachowsky	Control[1)]	3.7	1.7	84.8
et al. (1997a)	+ 1 g vit. E per day[2)]	29.6	2.3	91.3
	+ 5% false flax expeller	8.1	2.0	52.0
	+ 1 g vit. E per day[2)]	27.6	3.0	82.3
	+10% false flax expeller	4.4	1.9	60.7
	+ 1 g vit. E per day[2)]	19.0	2.0	72.4
Flachowsky	Control[1)]	5.4	1.8	12.5
et al. (1993)	+ 1 g vit. E per day[2)]	50.3	3.5	30.0
	+ 10% rapeseed	5.3	2.8	13.4
	+ 1 g vit. E per day[2)]	49.1	3.8	31.1
	+ 20% fullfat soybean	6.2	2.1	11.1
	+ 1 g vit. E per day[2)]	35.6	3.7	32.1
Gottschalk	Control[1)]	0.5	0.5	7.0
et al. (1994)	+ 1 g vit. E per day, 7 days before slaughtering	9.2	0.5	6.8
	+ 1 g vit. E per day, 14 days before slaughtering.	5.9	0.9	10.6
	+ 1 g vit. E per day, 21 days before slaughtering	8.6	1.1	12.8
Rosenbauer	Control[1)]	n. d.	2.4	9.4
et al. (1998)	+ 100 mg vit E per kg feed	n. d.	4.9	19.8
	+ 200 mg vit E per kg feed	n. d.	5.6	24.8
	+ 1.2 g vit. E per day[2)] (adequate to 100 mg per kg feed)	n. d.	4.5	19.9

[1)] Vitamin E content of control mixtures varied between 15 and 20 mg per kg
[2)] Vitamin E supplementation started 21 days before slaughtering

Table 3: Vitamin E content of food from broilers depending on vitamin E supplementation (SÜNDER and FLACHOWSKY, 1997)

Vitamin E supplementation (mg kg^{-1} feed)	Vitamin E content (mg kg^{-1}) Liver	Muscle Thigh	Muscle Breast
Control (20 mg per kg)	3.0	1.1	2.6
+ 100	11.7	4.9	7.2
+ 1 000	44.9	31.8	34.5
+ 10 000	158	90.5	88.7
+ 20 000	332	122	122

Table 4: Vitamin E content of eggs and carry over of vitamin E into eggs depending on vitamin E supplementation (SÜNDER et al., 1997a)

Vitamin E supplementation (mg kg^{-1} feed)	Vitamin E content µg g^{-1} yolk	Vitamin E content mg per egg	Carry over of vitamin E (% of supplementation into eggs)
Control (20 mg kg^{-1})	72	1.1	-
100	247	3.7	25
1000	1418	19.8	16
10 000	2600	35.3	3
20 000	3201	42.5	2

Carry over of vitamin E

Calculations of carry over of vitamin E from feed into food of animal origin are simple for milk and eggs. The products are mainly total used as food in both cases. Vitamin E is stored in some organs and tissues (e.g. some interior organs, fat, blood etc.) of the slaughtering body, but they are not always used as food for human nutrition.

Under consideration of data shown in tables 1 to 4 and some references carry over of additional vitamin E levels from feed into food of animal origin is shown in Table 5. The highest carry over values were calculated for eggs (Table 5) decreasing with higher vitamin E supplementation (Table 4).

In comparison to eggs the carry over of added vitamin E from feeds into milk or meat is very low (0.2 to 2%; Table 5). Of course it seems possible to improve the vitamin E supply of man via food of animal origin, but the efficiency is very low except eggs.

Higher vitamin E supplementation may improve some parameters of quality of food of animal origin, but its contributions for human nutrition is negligible. Furthermore the higher costs of vitamin E supplementation are mostly not repaid to the farmers.

Table 5: Influence of vitamin E supplementation on vitamin E content of food and carry over of vitamin E into food of animal origin (average from own experiments and added by references for milk and beef)

Food of animal origin	Vitamin E supply (mg kg^{-1} DM or supplementation)	Vitamin E content of food (mg l^{-1} or mg kg^{-1})	Carry over of vitamin E supplementation into food (% of supplementation)
Milk	50	1.2	-
	+ 1 g d^{-1}	1.8	1.2
	+ 3 g d^{-1}	2.0	0.5
Beef	40	2.0	-
	+ 1 g d^{-1}	4.0	0.2
Pork	20	2.0	-
	+ 100 mg kg^{-1} feed	4.0	0.5
Chicken	20	2.0	-
	+ 100 mg kg^{-1} feed	6.0	2.0
Egg	20	20	-
	+ 100 mg kg^{-1} feed	70	25

Summary

Some experiments with dairy cows, bulls, fattening pigs, broilers and layers were carried out to study the effects of abundant vitamin E levels on vitamin E content of foods of animal origin and to calculate the carry over of vitamin E into food.

Vitamin E supply to dairy cows increased vitamin E content of milk to small portions (e. g. from 1.2 to 1.8 mg kg^{-1} milk, when 1 g per animal per day was supplemented). An increase of the vitamin E supply to five times of the recommendations results in an increase of vitamin E concentration in meat by a factor of 2 and in eggs by a factor of 4. Apart from eggs the highest vitamin E concentrations were measured in liver and depot fat.

The highest carry over of additional vitamin E into foods of animal origin was measured for eggs (16 or 25% when 1000 or 100 mg vitamin E per kg feed were supplemented). It was below 2% for all other foods.

In consequence of the low carry over additional vitamin E amounts in animal nutrition to improve vitamin E supply of men could not be recommended except eggs.

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