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Status of vitamins E and A and β-carotene and health in organic dairy cows fed a diet without synthetic vitamins

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ABSTRACT

Synthetic vitamin supplementation is not consistent with organic production, so it is important to investigate whether dairy cows can maintain their health and production without synthetic vitamins being added to their diet. In basic dairy cow diets, provitamin A (β-carotene) and vitamin E are mainly found in pasture and in grass and legume silages, but the concentrations are highly variable. This study compared the vitamin status and health of cows without synthetic vitamin supplementation (NSV group) with control cows (CON group) fed synthetic vitamins according to Swedish recommendations (600 IU of vitamin E and 80,000 IU of vitamin A per cow per day) to investigate whether dairy cows can fulfill their requirements of vitamins A and E without supplementation with synthetic vitamins. Vitamin concentrations in blood plasma and milk, health, fertility, milk yield, and milk composition were measured in Swedish Holstein cows (n = 28) during 2 complete lactations. All cows were fed a 100% organic diet containing grass-legume silage, cold-pressed rapeseed cake, peas, cereal grains, and minerals. Blood samples were collected from each cow 3 wk before expected calving, at calving, and 3 wk, 3 to 5 mo, and 7 to 9 mo after calving. Samples of colostrum were taken and milk samples were collected 4 d after calving and at the same time as the 3 blood samplings after calving. The only difference in vitamin status between groups was found in colostrum in yr 1, when CON cows tended to have a higher concentration of α-tocopherol, and their β-carotene concentration was higher compared with NSV cows. The NSV cows tended to have more cases of mastitis than CON cows in yr 2. Within the NSV group, fewer cows were healthy and more cases of mastitis were observed in yr 2 than in yr 1. The groups did not differ in production parameters. In conclusion, the vitamin status in blood and milk of the studied cows indicated that cows in organic dairy production can fulfill their requirements of vitamins A and E without any supplementation of synthetic vitamins, except at the time around calving, when the requirements are high. However, the impaired health of NSV cows in yr 2 may indicate a long-term negative health effect in cows fed no synthetic vitamins.

Key words: α-tocopherol, β-carotene, retinol, organic milk production

INTRODUCTION

The international principles for organic farming do not approve the use of synthetic vitamins. Thus, diets for dairy cows in organic production must be based on naturally derived feeds (EC, 1999), and synthetic vitamins may only be used if required to fulfill the vitamin needs of the animals (EC, 2005). Consequently, it is important to investigate whether dairy cows can maintain their production and health throughout lactation without supplementation with synthetic vitamin A and E.

In basic dairy cow diets, vitamin E is mainly found in grass and forage legumes but also in unprocessed oilseeds (NRC, 2001). The most important function of vitamin E is its antioxidant effect and thereby its positive effects on the immune system (e.g., mammary gland health; Politis et al., 1996; Weiss et al., 1997). Moreover, vitamin E is involved in maintaining the oxidative stability and flavor of milk (Vagni et al., 2011). Natural vitamin E (*RRR*-α-tocopherol) found in feeds is not identical to synthetic vitamin E (all-*rac*-α-tocopheryl acetate), and has higher biological activity than synthetic vitamin E (Meglia et al., 2006; Dersjant-Li and Peisker, 2010; Vagni et al., 2011).

Vitamin A activity is defined in retinol equivalents. Retinol is not found in plants, but many feeds contain β-carotene (provitamin A) and most β-carotene is found in vegetative material (NRC, 2001). Carotenes are converted to retinol by enzymes in the cow intestinal mucosa, but large amounts of β-carotene are also absorbed without modification (Chew, 1987).

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Vitamin A and β-carotene have many diverse functions such as in reproduction, immune functions, and health (Chew, 1993; Kume and Toharmat, 2001). Similar to vitamin E, β-carotene is an antioxidant (Chew, 1987, 1993).

Grass and legume silages have higher contents of vitamin E and β-carotene than hay, whole-crop small grain silage, or corn silage, as reflected in the concentrations of vitamin E and β-carotene in milk from cows fed these different roughages (Agabriel et al., 2007; Mogensen et al., 2012). It has also been suggested that ruminal destruction of vitamin A decreases as the proportion of forage in the diet increases (Weiss et al., 1995). However, the concentrations of the natural forms of vitamin E (*RRR*-α-tocopherol) and β-carotene in silages are highly variable and relatively unstable (Calderón et al., 2007; Lindqvist et al., 2011; Lindqvist et al., 2012). In contrast, the synthetic forms of vitamin A (e.g., all-*trans* retinyl acetate) and E (all-*rac*-α-tocopheryl acetate) present in supplements are relatively stable throughout processing and storage (Coelho, 1991). Therefore, the amounts of vitamins fed to the cow are known more exactly when synthetic supplements are fed and, thus, the NRC recommends that the total vitamin A, D, and E requirements be met via dietary supplements (NRC, 2001).

In dairy cows, the highest need for vitamins occurs around calving, when the cows are exposed to physiological stress. Decreased DMI relative to milk production and vitamin losses with colostrum are not sufficient to explain the decrease, but vitamin partitioning may also be impaired (Drackley, 1999; Baldi, 2005).

The hypothesis in the present study was that organic feed rations based on high proportions of grass-legume silage of good nutritive value provide a substantial contribution of vitamins and thereby supply dairy cows with adequate amounts of α-tocopherol and β-carotene, except during the transition period around calving, when the requirements are high. Therefore, experiments were conducted to investigate whether high-producing dairy cows in organic production can fulfill their requirements of vitamins A and E without any supplementation of synthetic vitamins when fed a diet based on organic feeds chosen for high vitamin contents. To evaluate this, 2 groups of dairy cows were monitored during 2 lactations.

MATERIALS AND METHODS

Animals and Experimental Design

The experiment was approved by the Research Animal Ethics Committee (Swedish Board of Agriculture, Jönköping, Sweden) and conducted during 2 complete lactation periods in 2 consecutive years at Tingvall Organic Dairy Research Farm in southwest Sweden, which was owned by the Swedish Rural Economy and Agricultural Societies (Uddevalla, Sweden). The herd consisted of Swedish Holstein dairy cows with a rolling herd average annual milk yield of 9,873 and 10,383 kg of ECM per cow during yr 1 and 2, respectively, with 3.7% fat and 3.3% protein in the milk in both years. The cows were milked twice per day at 0530 and 1530 h. From early May until mid October, the cows were kept out on pasture, except for about 3 h around each milking. During the indoor period, they were kept in a loose-housing system. The 2 experimental groups, each of which comprised 14 cows, were housed in separate pens.

Cows were paired according to their expected calving date, lactation number, and previous 305-d milk yield (or breeding index for heifers), and then randomly allocated to 1 of 2 treatments: a 100% organic diet containing mineral feed without vitamins [no synthetic vitamins (**NSV**)] and a 100% organic diet containing the same mineral feed but including the synthetic vitamins A, D_3, and E [control (**CON**) with synthetic vitamins]. Vitamin supplementation started during the dry period, at least 1 mo before expected calving, and continued during lactation. All cows calved between November and February in yr 1 and between August and March in yr 2.

Diets

During the housed period, the cows were fed a partially mixed ration of grass-clover silage and rolled barley (also triticale in yr 2) ad libitum, supplemented with a barley/pea mixture, cold-pressed rapeseed cake, and mineral feed, in transponder-controlled automatic feeders. Cows were fed a minimum of 50% silage (calculated on a DM basis) in the first 3 mo after calving and thereafter a minimum of 60% silage, according to the standards for organic feeds (EC, 1999).

The mineral feed included 146 g of Ca, 65 g of P, 92 g of Mg, and 40 mg of Se per kilogram of DM. For CON cows, it also included 3,000 IU of vitamin E, 100,000 IU of vitamin D, and 400,000 IU of vitamin A per kilogram of DM. Minerals and vitamins were fed according to Swedish recommendations, which are based on NRC (2001) guidelines. Dry cows in the CON group were supplemented with 450 IU of vitamin E and 60,000 IU of vitamin A per day in the diet from the start of the experiment until calving. The calculated daily amounts offered by the basal diet (based on 9 kg of silage DM) of the dry cow were approximately 173 IU of vitamin E and 9,420 IU of vitamin A. The vitamin contents in the diet of lactating cows are shown in Table 1.