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Short communication

The stability of vitamin C and other vitamins in the diets of breeding hens

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ABSTRACT

The stability of vitamin C in mash and pelleted mixed feed was studied during a 12-week period of guaranteed storage time. This research involved three feed types: feed without the addition of ascorbic acid (AA) and mixed feed supplemented with 200 mg/kg AA in the form of crystalline or protected AA (Monophosphate, Lutavit® C Monophosphate 35). The other vitamins were part of a vitamin–mineral premix. Vitamin C concentrations were analysed using 14-day intervals, with other vitamins being evaluated at the beginning and after 4 and 12 weeks of storage. The interaction between the source of vitamin C and the pelleting ($P<0.001$), between the source of vitamin C and the storage time ($P<0.001$) and the combined effect of the pelleting and the storage time ($P<0.001$) was ascertained in the vitamin C content in the feed mixture. Monophosphate was highly stable in the mixture until the 10th week of storage and seems to be an appropriate source of vitamin C in animal feed. In contrast, crystalline AA had notably low stability. The process of pelleting of the diet had a different effect on the stability of the monitored vitamins. During storage, the stability of vitamin C and retinol was lower and α-tocopherol and β-carotene stability was higher in the pelleted feed than in the non-pelleted feed.

1. Introduction

Chickens may not have the ability to produce sufficient ascorbic acid (AA) to meet their physiological needs (Pardue and Thaxton, 1986). Vitamin C is an anti-stress factor and is therefore important for various types of poultry during periods of high temperatures. Ascorbic acid positively affects reproduction. Chickens require vitamin C for amino acid and mineral metabolism and for the synthesis of hormones, such as testosterone (McDowell, 1989). Thus, breeding poultry need ascorbic acid throughout the year.

The effects of dietary vitamin C in poultry can vary widely because of the low stability of previously added sources of ascorbic acid. However, vitamin C is subject to oxidative and enzymatic degradation to dehydroascorbic acid and subsequently diketogulonic acid; the vitamin therefore loses its potency (Nyyssonen et al., 2000). Various factors, including light, metal ions, alkaline pH and high temperature, influence the content of vitamin C in feed. High temperatures during extrusion significantly reduced the vitamins in fish feed (Marchetti et al., 1999; Anderson and Sunderland, 2002). Additionally, the stability of coated vitamin C in aquaculture feed was reduced by 50%, due to 110–150 °C temperatures during extrusion (Gadient and Fenster, 1994). In poultry, crystalline AA is still mostly added to the drinking water of breeding hens, which is quite impractical. The supplementation of pig feed with crystalline AA led to a decline of 31–44% of the initially

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Table 1
The composition of the control feed mixture.[a]

Ingredient	g/kg
Wheat	560
Maize	190
Wheat bran	10
Soybean meal	130
Fish meal	12
Rapeseed oil	10
Dicalcium phosphate	15
Sodium chloride	2
Fine limestone	65.8
DL-Methionine	0.2
Vitamin–mineral premix[b]	5
Analysed nutrient content[c]	g/kg
Dry matter	898
Crude protein	152
Fat	21
Crude fibre	33
Calcium	30.2
Total phosphorus	4.71
Non-phytate phosphorus	3.94
Calculated ME_N (MJ/kg)[d]	11.56

[a] Another experimental feed mixture was supplemented with 200 mg of vitamin C/kg in the form of crystalline ascorbic acid or ascorbic acid monophosphate.
[b] The vitamin–mineral premix provided the following per kg of diet: retinylacetate 2.5 mg, cholecalciferol 60 μg, DL-α-tocopheryl acetate 50 mg, niacin 20 mg, Ca pantothenate 6 mg, thiamine 1.5 mg, riboflavin 4 mg, pyridoxine 2 mg, folic acid 0.4 mg, biotin 0.06 mg, cobalamin 0.01 mg, choline Cl 250 mg, butylated hydroxytoluene 27 mg, Mn 60 mg, Zn 50 mg, Fe 30 mg, Cu 6 mg, I 0.7 mg, Co 0.3 mg, and Se 0.2 mg.
[c] The data are expressed as fed basis.
[d] Feed tables of Zelenka et al. (2007) were used for calculation of metabolisable energy (ME).

added amounts due to pelleting according to the above allowances of 150–600 mg/kg (Gebert et al., 2006). Today, several pharmaceutical companies offer stabilised vitamin C, which is designed for incorporation into animal feed.

Independent tests of the stability of AA in stored diets during guaranteed storage have not been conducted. There are particularly scarce data available concerning pig feed regarding the change of concentration of supplemented AA in mixed feed immediately after preparation, rather than during storage (Eichenberger et al., 2004; Lahučký et al., 2005; Gebert et al., 2006). Skřivan et al. (2012) reported on the stability of AA coated with ethyl cellulose in the feed of chickens after 5 weeks. The recommended storage time of mixed feed by manufacturers is up to 12 weeks. Therefore, the objective of this study was to investigate the stability of crystalline and stabilised AA in mash and pelleted feed for breeders over a period of 12 weeks. The stabilities of α-tocopherol, retinol and β-carotene were monitored simultaneously.

2. Materials and methods

2.1. Experimental design

The experiment was conducted for mixed feed for meat-type hens in reproductive and breeding farms without vitamin C addition (control, Table 1) and with mixed feeds enriched with AA (200 mg/kg) in two different forms: crystalline AA (Crystalline, content at least 999 g/kg; Trouw Nutrition Biofaktory s.r.o., Prague, Czech Republic) and protected AA (Monophosphate, Lutavit® C Monophosphate 35; produced by Orffa Nederland Feed B.V., Giessen, the Netherlands; provided by Trouw Nutrition Biofaktory s.r.o., Prague, Czech Republic). The protected Lutavit® contains at least 350 g/kg of AA; the active ingredient is L-ascorbic acid-2-monophosphate-calcium sodium salt × $3H_2O$; the molar mass is 319.1 g/mol; the bulk density is 0.6–0.8 g/cm^3; and the particle size is 98% <0.5 mm. Ascorbic acid was supplied in a mixture as part of the vitamin–mineral premix Aminovitan NP-M (Trouw Nutrition Biofaktory s.r.o., Prague, Czech Republic). The time difference between preparing the vitamin–mineral premix and its mixing in hen feed was 5 days. The mixed feed was mixed by the International Poultry Testing of the Czech Republic (MTD, s.p., branch in Lysá nad Labem, Czech Republic). Two hundred kilogrammes of mixed feed was produced for each form of AA and control, of which 100 kg was not pelleted, and 100 kg was pelleted. The pelleting process began with 20 min of homogenisation. The homogenised mixture was steamed using a gas generator at a temperature of 60 °C. The pressure generated by pushing mash through a pellet mill increased the temperature by 10 °C. The pellets were at this temperature for only 1 min, after which time they were fan-cooled at the ambient temperature (max. of up to 5 °C higher than the ambient temperature). The pellet mill die had holes that measured 3.0 mm in diameter.