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Vitamin K-biofortification of eggs: effect on egg quality and hen performance parameters

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Abstract
Vitamin K has important physiological functions which relate to blood coagulation (its classical role), bone health, inhibition of arterial calcification, as well as anti-inflammatory effects. National nutrition survey data have shown that over half of all adults in Ireland and the UK have low vitamin K_1 intakes (£1 μg/kg body weight/d). Vitamin K biofortification of food may be an important complementary food-based approach for improving vitamin K intakes. Our study aimed to explore the feasibility of producing vitamin K-biofortified eggs via increasing the vitamin K_3 content of the hen diet, and to examine any effects on hen performance and egg/eggshell quality parameters. A 12-week hen feeding trial was conducted in the Agri-Food and Biosciences Institute, Belfast, UK. Hyline chickens (n = 128) were randomized into 4 treatment (T) groups (n = 32 hens/group) and fed diets containing 3 (T1-industry standard), 12.9 (T2), 23.7 (T3) and 45.7 (T4) mg vitamin K_3/kg of feed. Hens were provided feed *ad libitum* and feed intake was recorded weekly. Eggs were collected daily and weighed. While egg quality and vitamin K content was assessed at week 0, 4, 6, 8 and 12, the trial endpoint (week 12) data was prioritized for the current analysis. Total vitamin K content (i.e., vitamin K_1 plus menaquinone (MK)-4 and MK-7) of composite samples (n = 12 eggs/treatment), measured using a novel, sensitive liquid chromatography-mass spectrometry method at Teagasc, increased from 22.4 μg/100 g (whole egg) in T1 (control and commercial level of vitamin K_3) to 57.8 μg/100 g in T4. MK-4 was the most abundant form of vitamin K found in the eggs. Eggshell weight and eggshell thickness in T2 and T3 (but not T4) were significantly higher than in T1 (by 20–28%, $P < 0.05$). Likewise, based on colourimetric assessment, yellowness (parameter b^*) of the egg yolk in all three biofortified groups was significantly higher compared to T1 (by 27–45%, $P < 0.05$). Haugh unit of the eggs and hen performance parameters, such as feed intake, feed conversion ratio and egg production, were unaffected by vitamin K-biofortification. In conclusion, increasing the level of addition of vitamin K_3 to hen feed significantly increased the total vitamin K content of eggs, and without any evidence of negative effects on egg quality or hen performance. Consumption of an average sized (60 g) vitamin K-biofortified egg could contribute an additional 35 μg total vitamin K. The effects on eggshell parameters could be of importance in terms of revenue loss due to breakages.

Conflict of Interest
There is no conflict of interest