Liposoluble Vitamins Importance into Laying Hens Nutrition

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Abstract

Liposoluble vitamins play an important role in poultry metabolism. Vitamin A assures normal growth and development, reproduction performances, and immune function. Vitamin D is requested for proper calcium absorption, prevents oxidative stress, and helps the immune system. Also, vitamin E, which cannot be synthesized by poultry, is crucial for growth and reproduction, improves the immunity system, efficient against oxidative stability. Vitamin K is a key factor for the blood clotting process, has anti-inflammatory effects, and improves bone quality and feed efficiency. Vitamin requirements in laying hens' diets increased compared to the minimum levels published 28 years ago in National Research Council, therefore became vital to update it. Due to the poultry and feed industry's increasing challenges and demands the present requirements must sustain the development and productive potential of modern poultry strains. Therefore it is mandatory that experimental data with different inclusion levels of liposoluble vitamins and with positive effects on growth, production, and health parameters be taken into consideration. Certainly, updated information about liposoluble vitamin variability and efficiency transfer rate from diet to egg would help tremendously the farmers interested in foods biofortification by dietary vitamin supplementation. Overall, liposoluble vitamins are considered essential micronutrients very important to assure balanced poultry nutrition that provides an optimized animal status health.

Keywords: eggs, diet, laying hens, liposoluble vitamins

1. Introduction

Considerations about liposoluble vitamins importance in laying hens nutrition

Liposoluble vitamins A, D, E, and K are present in foodstuffs/feedstuffs in association with lipids, being absorbed along with dietary fats, by mechanisms similar to those involved in fat absorption. According to some authors an adequate bile flow and good micelle formation can facilitate the liposoluble vitamin absorption [1]. These vitamins consisting only of carbon, hydrogen, and oxygen are essential during all developmental phases of poultry, and their absence or low absorption will cause metabolic deficiency [2]. Vitamins A, D, E, K are stored for longer periods of time and in appreciable amounts within animal body (liver, kidney, adipose tissues), therefore it poses a greater risk for toxicity and can cause serious problems [3, 4]. Liposoluble vitamins are excreted primarily in the feces via the bile [5]. Some authors consider that providing a proper liposoluble level of 7500 IU vitamin A, 2000 IU vitamin D3, 10 IU vitamin E and 1.8 mg vitamin K per kilogram of diet will assure adequate production performances [6]. Nonetheless, these vitamins levels requires supplementation (2500 IU vitamin A, 250 IU vitamin D3, 4 IU vitamin E, 0.4 mg vitamin K3/kg

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diet) as proposed by the National Research Council (NRC, 1994) [7].

2. Discussions

Vitamin A importance in laying hens nutrition

Vitamin A is a product of animal metabolism, actually, vitamin A does not exists in plants itself but involves precursors compounds with the biological activity of retinol particularly ß-carotene, α-carotene, ß-cryptoxanthin, provided by green, yellow, orange vegetables/fruits and retinyl esters and retinol itself, found mainly in liver, eggs, dairy products [8]. These precursors (carotenoids) will be converted into vitamin A by a specific enzyme located in the intestinal walls of animals. Vitamin A is absorbed in the gut in the presence of bile salts and intestinal fluid [9].

Among the richest sources of vitamin A (not the case if the animal was fed an extended period a vitamin A-deficient diet) ranks the fish oils (whale liver oil 400 000 IU/g, cod liver oil 4000 IU/g), butter (35 IU/g), egg yolk (10 IU/g), milk 1.5 (35 IU/g). Also, the content of vitamin A can be reduced when overcooked or exposed to ultraviolet light [10]. Vitamin A is important for growth, reproduction and immunity enhancement, therefore numerous studies linked the increased susceptibility to infections to vitamin A deficiency. The amount of vitamin A required per hen daily is 2500 IU in White-egg layers (at 100 g feed/hen/day) according to NRC, 1994 [7].

Some authors, recommend for laying hens a level of 9 000 UI/kg feed vitamin A [11]. When vitamin A supplementation effects (3 000, 6 000, 9 000, 12 000 IU/kg) of heat-stressed hens (31.5°C) were investigated, an increased egg weight and significant effect on Newcastle disease virus antibody titer and alpha-naphthyl acetate esterase (ANAE)-positive cells proportion were noticed [12]. Another study experimented supplementary vitamin A levels of 16,000 IU/kg and selenium (0.25 mg/kg) combination on laying hens under heat stress conditions found that all productive traits were improved except feed intake [13].

Liu et al, 2012 used β-cryptoxanthin-biofortified maize to obtain egg biofortification for provitamin A carotenoids (α-, β-carotene, β-cryptoxanthin) and to increase egg colour taking advantage of laying hen potential to deposit carotenoids into egg yolk [14].

Vitamin D importance in laying hens nutrition

Vitamin D called also "sunshine vitamin" refers to a group of chemically related compounds with antirachitic activity. This group has two major natural sources of vitamin D: cholecalciferol (vitamin D3, which occurs in animals) and ergocalciferol (vitamin D2, which occurs predominantly in plants) [15]. Vitamin D is important to maintain calcium and phosphorus homeostasis [16]. When dietary vitamin D level is scarce impaired bone mineralization (rickets or osteomalacia) can result [17]. Sufficient sunlight exposure determines a normal level of vitamin D within animal body therefore dietary supplementation would not be necessary. Also, sun-cured hays are sources of vitamin D [18]. According to a meta-analysis, vitamin D3 is more effective than vitamin D2 at increasing the levels of 25(OH)D serum concentrations, therefore vitamin D3 may become the preferred option for supplementation [19]. Cooking process may affect vitamin D activity, however depends greatly on food and the heating method used [20]. The vitamin D metabolism into circulating form (25(OH)D) and hormonal form (1,25(OH)2D) takes place in the liver, kidney and tissues (skin, immune system cells, prostate, breast, parathyroid gland, intestinal epithelium) in which 1,25(OH)2D produced has paracrine/autocrine function [21]. For its absorption, vitamin D requires bile salts (mainly in the duodenum), forming micelles and chylomicrons for transport. The cutaneous synthesis remains the main source of vitamin D. The richest vitamin D food sources are mainly of animal origin as fatty fish, eggs, liver [22].

According to Koreleski and Swiatkiewicz, 2005b [23] the high incidence of rickets and dyschondroplasia in chickens fed D3-rich diets indicates clearly an insufficient transformation of cholecalciferol in the liver and kidney (to 25-OHD3 and 1,25-(OH)2-D3).

According to NRC, 1994 [7] vitamin D3 requirements is 300 IU/100 g/laying hen/day whereas commercial recommendations varies between 2500-3500 IU/100 g/laying hen/day [24].

A vitamin D3 supplementation of 500 IU, 1500 IU, 3000 IU/kg to the basal diet increased significantly egg production, egg weight, and egg quality [25]. Other authors adding up to 102 200

IU D3/kg of diet noticed no negative effects on laying hen performance or egg quality [26].

Supplementation of laying hens diets up to 35 014 IU D3/kg feed enhanced production performances, skeletal quality, yolk D3 content, eggshell quality. A higher level of 68 348 IU/ kg feed of D3 reduced growth and decreased production performances [27].

Vitamin E importance in laying hens nutrition

Vitamin E is recognized as an essential nutrient and an indispensable cellular antioxidant for all species of animals, important against free-radical injury; enhancing the immune response [28].

It comprises four tocopherols (α-, β-, γ-, δ-) and four tocotrienols (α-, β-, γ-, δ-), of which α-tocopherol and γ-tocopherol are frequently encountered within our diet and *in vivo* [29]. Although the α-tocopherol is the most active form which nutritionists prefer to take into account versus the total tocopherol values, recent researches indicated a greater antioxidant potential of tocotrienols compared to tocopherols [30]. Widespread in nature, vegetable oils, cereal products containing oils, eggs, liver. In nature, the synthesis of vitamin E is a function of plants, and thus, their products are by far the principal sources. Vitamin E is generally abundant in whole cereal grains, especially in germ. Different values of α-tocopherol were reported with feeds containing threefold to tenfold values [31].

Particularly in monogastrics, the vitamin E requirements are high related by the amount and the degree of dietary fat, the antioxidant presence, the minerals content (Se, Fe, Co and sulphur aminoacids), the animal physiological status but also depends on the its variability feedstuffs content and poor stability during feeds storage [32]. Compared to commercial recommendations, vitamin requirements according to NRC in 1994 [7] were as follows: 5 IU vitamin E (100g/laying hen/day) [32] whereas others [33] recommended 50 IU vitamin E (100g/laying hen/day) or 15-30 IU vitamin E (100g/laying hen/day) [34]. In other experimental studies supplementation with 200 mg/kg of vitamin E significantly improved egg production and yolk percentage ($p<0.05$). Increasing the dietary levels of vitamin E caused a decrease in cholesterol and an increase in the α-tocopherol concentration of the egg yolk and serum ($p<0.05$) [35]. Also, there are authors that stated that 25-50 IU vitamin E/kg had most immunomodulatory effects therefore dietary higher levels would be less efficacious [36]. The efficiency transfer of vitamin E from diets to egg is medium (15-25%) according to Naber, (1993) [37].

Vitamin K importance in laying hens nutrition

Vitamin K referred as coagulation and antihemorrhagic vitamin, prothrombin factor, synthesized by intestinal microorganisms, was the last discovered among the liposoluble vitamins [30]. It is a compounds family with a common chemical structure of 2-methyl-1,4-naphthoquinone [38] that includes phylloquinone (vitamin K1) present mostly in green leafy vegetable and a series of menaquinones (vitamin K2), of bacterian origine, present in animal-based and fermented foods [39]. Vitamin K3 (or menadione) is a synthetic form without a side chain.

Vitamin K serves as a cofactor for γ-glutamate carboxylase, enzyme that catalyzes the glutamate conversion into γ-carboxylated glutamate within 17 different proteins [40].

According to Hidiroglou et al., (1992) [32] vitamin K requirements for poultry ranges between 0.5–1.8 mg/kg feed. Numerous studies have demonstrated the vitamin K is specifically concentrated and retained in the liver [30]. Several authors [41] experimented different levels of K_3 vitamin (2.0 and 4.0 mg/kg) compared to C group (0.5 mg/kg), especially in aged laying hens (87-week-old), recording an increase yolk coloration and eggshell quality, an improved oxidative status of eggshell gland therefore recommended an optimal dietary K_3 level. Eggs biofortification with vitamin K was tried by Suzuki and Okamoto [42] who obtained, by adding 100- to 1000-fold over control level an increase of egg yolk yellowness and an eggshell weight and thickness improvement.

Others researchers included 25 mg/kg hen feed which doubled the vitamin K content of the egg, increased eggshell weight and thickness [43].

The relative efficiency transfer of vitamin K from diet to egg is relatively low from 5-10%. At an equivalent dietary level of 5.2 mg it is encountered an output in egg of 25μg [37].

3. Conclusions

Taking into consideration how fast and continuous the modern poultry growth and production is

changing it is mandatory to update liposoluble vitamins requirements to obtain the best production potential by using both nutrition and genetics. Assuring the right vitamin balance in poultry nutrition prevents any future flock efficiency problems.

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