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Original Research Article

Effects of essential oils on performance, egg quality, nutrient digestibility and yolk fatty acid profile in laying hens

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ABSTRACT

The study was conducted to investigate the effect of essential oils on performance, egg quality, nutrient digestibility and yolk fatty acid profile in laying hens. A total of 960 *Lohmann* laying hens aged 53 weeks were enrolled, under 4 different treatment diets supplemented with 0, 50, 100 and 150 mg/kg essential oils (Enviva EO, Dupont Nutrition Biosciences ApS, Denmark), respectively. Each treatment was replicated 8 times with 30 birds each. Birds were fed dietary treatment diets for 12 weeks (54 to 65 weeks). For data recording and analysis, a 12-week period was divided into 3 periods of 4 weeks' duration each: period 1 (54 to 57 weeks), period 2 (58 to 61 weeks), and period 3 (62 to 65 weeks). For the diet supplemented with Enviva EO, hen-day egg production and the feed conversion ratio (FCR) were significantly improved ($P < 0.05$) at weeks 58 to 61, and the eggshell thickness was significantly increased ($P < 0.05$) at week 65. However, egg production, egg weight, feed intake, FCR and other egg quality parameters (albumen height, Haugh unit, egg yolk color and eggshell strength) were not affected by the dietary treatment. In addition, compared with the control diet, protein digestibility in the 100 mg/kg Enviva EO treatment group was significantly increased ($P < 0.05$), and fat digestibility in the 100 and 150 mg/kg Enviva EO treatment groups was significantly decreased ($P < 0.05$), but Enviva EO had no effect on energy apparent digestibility. Saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) gradually decreased and polyunsaturated fatty acid (PUFA) increased with Enviva EO supplementation, but the difference was not significant. The data suggested that the supplementation of essential oils (Enviva EO) in laying hen diet did not show a significant positive effect on performance and yolk fatty acid composition but it tended to increase eggshell thickness and protein digestibility, especially at the dose of 50 mg/kg.

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1. Introduction

Essential oils (EOs) are obtained from plant materials (flowers, herbs, leaves, roots, etc.), which are complex mixture of various components, such as terpenes, aldehydes, esters, alcohols and other chemical molecules. Essential oils have been employed in animal diets for their antimicrobial (Lee et al., 2004), antibacterial (Srinivasan, 2004), antioxidant (Placha et al., 2010) and digestive stimulant properties (Platel and Srinivasan, 2004). Over the past decade, EOs have been regarded as the possible antibiotic-substitute for animals.

There have been a number of studies about the use of EOs on broilers chickens. Çabuk et al. (2006) reported dietary supplementation of essential oil mixture significantly increased egg production and improved feed conversion ratio (FCR) compared with control. Otherwise, Amad et al. (2011) reported that the apparent ileal digestibility of crude ash, crude protein, crude fat, calcium, and phosphorus showed a linear increase related to the increase of phytogenic feed additive in the diet. On the other hand, research on laying hens found that diet supplemented with EOs of thyme, sage, and rosemary (Bölükbasi et al., 2008) and essential oil mixture (EOM, Çabuk et al., 2006) improved performance, immune response, and eggshell quality of laying hens. And, Olgun (2016) also reported that egg weight, egg mass and eggshell thickness were positively affected by EOM supplementation. On the contrary,

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research also showed that the different dietary levels of EOM had no significant effect on performance parameters, damaged eggs, eggshell weight (Olgun and Yildiz, 2014). However, these previous studies on the EOs in the layers were mainly focused on the production performance, egg quality and nutrient digestibility, and the results are inconsistent.

Lipid composition of chicken eggs is a primary area of consumer concern due to the relationship between dietary lipids and the development of coronary heart disease (Simopoulos and Salem, 1992). Feeding strategies may change the fatty acid composition in eggs (Yi et al., 2014). Essential oils have beneficial influence on lipid metabolism (Acamovic and Brooker, 2005). Since there have been no reports about the effect of yolk diet supplemented with EOs on the fatty acid composition, the study was planned to evaluate the effect of EOs (Enviva EO) on performance, egg quality, nutrient digestibility and yolk fatty acid profile in laying hens.

2. Materials and methods

2.1. Experimental birds, diet and management

The animal experiment was conducted in accordance with the principles of Animal Care and Use Committee of Sichuan Agricultural University (Ya'an, China). A total of 960 *Lohmann* laying hens aged 53 weeks were enrolled in the study, and diets were supplemented with EOs (Enviva EO, Dupont Nutrition Biosciences ApS, Denmark) at the concentrations of 0, 50, 100 and 150 mg/kg, respectively were provided for 12 weeks (54 to 65 weeks). Enviva EO was a commercial product including thyoml 13.5% and cinnamaldehyde 4.5% as the active components. Eight replicates were set for each treatment with 30 birds in each replicate.

All hens were housed in an environmentally controlled house with temperature maintained at approximately 24 °C. The house had controlled ventilation and lighting (16L:8D). All hens were supplied with diet and water for *ad libitum* consumption.

The hens were fed diets in mash form during the experiment. The basal diet was formulated using maize and soybean meal with composition and nutrient levels in line with Agricultural Trade Standardization of China (NY/T33-2004) (Table 1). For experimental diets, experimental diet of the maximum and minimum concentration was first mixed separately and then mixed together for the preparation of subsequent experiments diets. All diets contained a standard dose of Phyzyme XP phytase (500 FTU/kg feed, Dupont Nutrition Biosciences ApS, Denmark).

Table 1
Ingredients and chemical composition of the basal diet (dry matter basis).

Item	Content, %
Ingredient	
Corn	54.5
Wheat	10.0
Soybean meal	16.85
Rapeseed meal	4.0
Rice bran meal	3.5
Corn protein powder	0.60
Soybean oil	0.25
Limestone	8.4
Dicalcium phosphate	0.62
Lysine-HCl (70%)	0.15
DL-Methionine	0.09
Salt	0.4
Choline chloride	0.1
Vitamin premix[a]	0.03
Mineral premix[b]	0.5
Phyzyme XP 5000G	0.01
Total	100
Chemical composition[c]	
ME, MJ/kg	11.0
Crude protein	15.3
Calcium	3.8
Available phosphorus	0.35
Lysine	0.75
Methionine	0.35
Methionine + Cystine	0.54
Threonine	0.58
Tryptophan	0.19

[a] Provided per kilogram of diet: retinyl acetate, 3.1 mg; cholecalciferol, 0.0375 mg; DL-α-tocopheryl acetate, 7.5 mg; thiamin, 0.6 mg; riboflavin, 4.8 mg; pyridoxine hydrochloride, 1.5 mg; cyanocobalamin, 0.009 mg; calcium-D-pantothenate, 7.5 mg; folic acid, 0.15 mg; niacin, 20 mg.
[b] Provided per kilogram of diet: copper ($CuSO_4 \cdot 5H_2O$), 6 mg; iron ($FeSO_4 \cdot H_2O$), 60 mg; zinc ($ZnSO_4 \cdot H_2O$), 80 mg; manganese ($MnSO_4 \cdot H_2O$), 60 mg; selenium ($NaSeO_3$), 0.3 mg; iodine (KI), 0.35 mg.
[c] The value of crude protein was analyzed and the value of metabolizable energy (ME) was calculated, others were calculated values.

2.2. Performance parameters

Mortality was recorded daily. Eggs were collected daily and the egg production percentage was expressed on a hen-day basis during period 1 (54 to 57 weeks), period 2 (58 to 61 weeks), and period 3 (62 to 65 weeks) and overall study intervals. Egg weight was recorded daily throughout the experimental period. Feed intake was recorded and the FCR was calculated for each period.

2.3. Egg quality parameters

To determine egg quality indices in every 4-week period, 24 eggs were randomly collected per treatment (3 eggs per replicate) to determine albumen height, Haugh units, yolk color, eggshell thickness and eggshell strength. Albumen height, Haugh units and yolk color were measured by EMT-5200 (Robotmation, Japan). Eggshell thickness was measured at 3 different sites (the upper and lower end, and middle) by using a micrometer screw gauge. An average of 3 thickness values measured from each egg was used to describe eggshell thickness. Eggshell strength was determined by EFR-01 (ORKA, Israel).

2.4. Nutrient digestibility

At the end of experiment, a total of 32 healthy laying hens (1 bird randomly selected from each replicate) were placed in metabolic cages, which were used for collecting excreta. Excreta samples of each hen were collected and immediately stored at −20 °C. During collection, care was taken to avoid contamination from feathers, feed, and foreign materials. Samples of the feed and excreta were analyzed for moisture, protein, and other extract, as described by the AOAC International (2000). The gross energy was determined using adiabatic bomb calorimetry (Parr Instrument Company, IL, USA).

2.5. Fatty acid profile of egg yolk

Fatty acids of the egg yolk were quantified by using gas chromatography. Fatty acid methyl esters were separated using a GC-9A gas chromatograph equipped with a flame ionization detector and a silica capillary column. Nitrogen was used as the carrier gas with a flow rate of 35 mL/min. The pressure of hydrogen and air was set at 0.5 kg/cm. The temperature of the injector and detector was maintained at 250 °C. Fatty acid methyl esters were identified

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