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Glycerin and lecithin inclusion in diets for brown egg-laying hens: Effects on egg production and nutrient digestibility

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ABSTRACT

The effects of the inclusion of raw glycerin (GLYC) and lecithin in the diet on egg production, egg quality and total tract apparent retention (TTAR) of dietary components was studied in brown egg-laying hens from 23 to 51 wk of age. The experimental design was completely randomized with six diets combined as a 2×3 factorial with two levels of GLYC (0 vs. 70 g/kg) and three animal fat to lecithin ratios (40:0, 20:20 and 0:40 g/kg). Each treatment was replicated eight times and the experimental unit was a cage with ten hens. Production was recorded by replicate every 28-d period and cumulatively. For the entire experiment, the inclusion of GLYC in the diet hindered feed conversion ratio per kilogram of eggs (2.071 vs. 2.039; $P < 0.05$) but did not affect any of the other production or egg quality traits studied. The replacement of animal fat by lecithin (40:0, 20:20 and 0:40 g/kg) increased egg weight (60.1, 60.7 and 61.8 g, respectively; $P < 0.001$) and egg mass production (56.8, 57.5 and 58.8 g/d, respectively; $P < 0.01$) and improved yolk color as measured by the DSM color fan (9.2, 9.2 and 9.5, respectively; $P < 0.001$) and feed conversion ratio per kilogram of eggs (2.072, 2.068 and 2.027, respectively; $P < 0.05$). Feed intake, egg production and body weight gain, however, were not affected. The inclusion of GLYC in the diet did not affect nutrient retention but lecithin inclusion improved TTAR of dry matter ($P < 0.05$), organic matter ($P < 0.05$), ether extract ($P < 0.001$) and gross energy ($P < 0.001$). In summary, the inclusion of 70 g glycerol/kg diet hindered feed conversion ratio per kilogram of eggs but did not affect any other production or digestibility trait. The replacement of animal fat by lecithin improved egg weight, egg yolk color and nutrient digestibility. Consequently, lecithin can be used as a lipid source in laying hen diets with beneficial effects on egg production.

Abbreviations: AME_n, apparent metabolisable energy, corrected for nitrogen; BWG, body weight gain; CP, crude protein; DM, dry matter; EE, ether extract; FA, fatty acid; FCR, feed conversion ratio; GMD, geometric mean diameter; GSD, geometric standard deviation; GE, gross energy; LNA, linoleic acid; MIU, moisture, impurities and unsaponifiables; N, nitrogen; OM, organic matter; GLYC, raw glycerin; RCF, Roche colour fan; TTAR, total tract apparent retention.

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1. Introduction

Raw glycerin, a coproduct of the ethanol industry, is an attractive energy source that can replace part of the cereal grain in poultry diets and contribute to reduce feed cost (Lammers et al., 2008; Swiatkiewicz and Koreleski, 2009; Mandalawi et al., 2014). Glycerol, a precursor of glyceraldehyde 3-phosphate, is an intermediate in the lipogenesis and gluconeogenesis pathways and yields energy through the glycolytic and tricarboxylic-acid pathways (Brisson et al., 2001; Lammers et al., 2008). The commercial product, raw glycerin (GLYC), is recognized as safe when used in accordance with good manufacturing and feeding practices (Code of Federal Regulations, 2004). Raw glycerin contains variable amounts of water and ash and its nutritive value depends primarily on the glycerol content. The maximum level of inclusion of GLYC in laying hen diets for optimal production, has been estimated within the range of 50–100 g/kg (Lammers et al., 2008; Swiatkiewicz and Koreleski, 2009; Németh et al., 2013). Also, the inclusion of GLYC in broiler diets increased dry matter (DM) and gross energy (GE) retention (Kim et al., 2013; Mandalawi et al., 2014). In spite of the commercial interest for using GLYC as an energy source in the diet, little information is available on the effects of GLYC on total tract apparent retention (TTAR) of dietary components and egg quality in laying hens.

Lecithin is a by-product of the oil refining industry. Soybeans are the largest source of commercially available raw lecithin. Commercial raw soy lecithin is a combination of polar lipids (mostly phospholipids and glycolipids) and oil at an approximate ratio of 60:40 and has a high content of unsaturated fatty acids (FA) (van Nieuwenhuyzen and Tomás, 2008; Mateos et al., 2012). In addition, soy lecithin is rich in phospholipids a fraction of the oil with important emulsifying and anti-oxidant properties. The inclusion of raw lecithin in the diet could improve lipid digestibility and liver function, effects that should be more pronounced in birds fed diets rich in saturated fats because of the key role of unsaturated FA and phospholipids in micelle formation (An et al., 1997; Huang et al., 2007).

The information available on the effects of raw lecithin inclusion in laying hens diets as a replacement of animal fat is scarce. Moreover, no published report is available on the effects of the inclusion GLYC and lecithin in the diet and their interaction on nutrient digestibility and performance of laying hens. We hypothesized that moderate amounts of GLYC could be used in diets for laying hens without affecting performance and that the inclusion of lecithin in the diet, at the expense of animal fat, could improve FA digestibility, nutrient retention and egg weight because of the easier incorporation into the yolk of dietary phospholipids, as compared with saturated, non-polar fats. The aim of this research was to evaluate the effect of the inclusion of raw glycerin and lecithin in the diet and their interaction on performance and nutrient retention of brown egg-laying hens from 23 to 51 wk of age.

2. Materials and methods

All experimental procedures were approved (PROEX 007/15) by the animal Ethics Committee of the Universidad Politécnica de Madrid and were in compliance with the Spanish Guidelines for the Care and Use of Animals in Research (Boletín Oficial del Estado, 2007).

2.1. Glycerin, lecithin and animal fat

The batch of GLYC used was a by-product of the biofuel industry from soybean oil and contained by analyses 810 g glycerol and 590 mg methanol/kg. The batch of raw lecithin was a by-product of the biodiesel industry from soy oil and contained 600 g polar lipids/kg. The animal fat was obtained from non-edible, out of date, pork parts (mostly hams and shoulders) after grinding and cooking the original materials at 3 bars and 133 °C for 20 min (Woodgate and Van der Veen, 2004). The chemical composition of the GLYC and the lipid sources used is shown in Table 1.

2.2. Husbandry, diets and experimental design

In total, 480 Lohmann Brown hens were housed in an environmentally controlled barn at 23 wk of age. At arrival to the experimental station, the hens were weighed individually and placed in groups of ten with similar average body weight in 48 enriched cages (40 cm × 80 cm × 68 cm; Facco S.p.A., Padova, Italy) provided with an open trough feeder and two nipple drinkers. The temperature inside the barn was recorded daily with average values that varied from 26 ± 2 °C in July (first period of the experiment) to 24 ± 2 °C in March (last period of the experiment). The light program consisted of 16 h light per day. All diets were based on maize and soybean meal and included 40 g supplemental fat/kg. The diets were formulated to have similar nutritive value according to Fundación Española Desarrollo Nutrición Animal (2010) and contained, on calculated bases, 11.51 MJ apparent metabolisable energy corrected for nitrogen (AME_n), 165 g crude protein and 7.3 g digestible Lys per kilogram. Diets were fed in mash form. The diets that included 70 g GLYC/kg had less maize and more soybean meal than the diets without GLYC. Lecithin, at 20 or 40 g/kg, was incorporated into the corresponding experimental diets at the expense (wt:wt) of the animal fat. In the formulation of the diets, no attempt was made to equalize the AME_n concentration of the diets, as a consequence of differences in energy content of the two fat sources used, because the AME_n of the lecithin in laying hen diets is not well established, with values ranging from 27.5 (Peña et al., 2014) to 35.5 MJ/kg (Mateos et al., 2012). Two batches of experimental diets were manufactured; the first batch was used for the first