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Egg Production of Hens Fed Homemade or Commercial Feed in a Cage-Free System

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ABSTRACT

Objective: To evaluate two types of feed (homemade or commercial), in egg production (EP, %), egg weight (EW, g), and egg mass (EM, g bird^{-1} d^{-1}), of hens in a cage-free system.

Methodology: Sixty hens aged 37 weeks (Rhode Island Red and Barred Plymouth Rock) were allocated to two treatments: COM, 150 g of commercial feed bird^{-1} d^{-1} and CAS, 150 g of homemade feed bird^{-1} d^{-1}. The birds were managed in a cage-free system with access to a paddock of white clover (*Trifolium repens* L.). EP, EW and EM were evaluated for 11 weeks.

Results: EP was different between treatments ($P<0.05$) in the last four weeks of observation. In this time, the COM birds laid 17 to 24% more than CAS birds. The EW produced by birds from the COM group (59.1 to 60.7 g) was greater ($P<0.05$) than that of the CAS birds (55.0 to 57.0 g). In the second half of the study period, a lower EM ($P<0.05$) was observed in the CAS treatment (24.7 to 31.8 g bird^{-1} d^{-1}) compared to the COM treatment (39.7 to. 41.8 g bird^{-1} d^{-1}).

Study Implications: The results obtained are only valid for the types of concentrate evaluated and under the specified experimental conditions.

Conclusions: The homemade feed reduces the productive performance of hens in a cage-free system in terms of EP, EW, and EM, when compared to the commercial feed.

Keywords: homemade feed, egg production, cage-free system.

INTRODUCTION

In Latin America, backyard poultry farming produces up to 70% of the eggs and poultry meat consumed by rural families (Soler and Fonseca, 2011), signaling its importance (Mottet and Tempio, 2017) and function as a tool for reducing poverty (Sonaiya, 2008; Abebe and Tesfaye, 2017). In poultry farming, animal feed can represent 60 to 90% of the production costs (Gunaratne,

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2013). Industrial poultry feed is made primarily with corn and soybean meal as energy and protein sources, respectively. However, poultry farming in developing countries oftentimes depends on the import of these ingredients (Ravindran, 2013a). In contrast to intensive production, birds in a backyard system look for feed themselves in the areas surrounding a house (food waste, insects, forage) and sometimes receive a supplement (maize, commercial feed, etc.) (Ravindran, 2013b; Sonaiya, 2008; Gerber *et al*., 2013). This suggests that their diet is not balanced and constant in time, which contrasts with the fact that a balanced diet is prerequisite to optimal productive performance of birds (Ravindran, 2013b). In the type of mentioned poultry production, access to materials used for birds' feed in an industrial production system represents an economical and logistical challenge. Therefore, practical and economical diets are needed, based on locally-available feed sources that ensure an optimal productive performance of the birds (Chadd, 2008).

The Food and Agriculture Organization of the United Nation's (FAO) Special Programme for Food Security (PESA) has strongly promoted backyard poultry production in Mexico. Through this program, close to 117,500 poultry projects were promoted nationally between 2007 and 2012 (UTN-FAO, 2013). The PESA recommended the use of homemade feed based on easily accessible ingredients in rural projects (PESA, 2005; PESA, 2007; PESA, 2010). Although there is precedent for egg production based on homemade feed (Aganga *et al*., 2003; Cahuec-Maas, 2017; Mutayoba *et al*., 2012), to our knowledge, the respective information is scarce in Mexico. A recommendation of homemade feed should be based on the information about the nutritional needs of the birds, the local availability of ingredients, their nutritional quality (Chadd, 2008), and a systematic evaluation of their effect on the productive performance of the animals (Soler and Fonseca, 2011). The objective of the present study was to evaluate the effect of the type of feed (commercial and homemade) on egg production, egg weight, and egg mass of hens in a cage-free system.

MATERIALS AND METHODS

The experiment was conducted from April to June of 2019, in the Experimental Poultry Farm of the Department of Zootechnics at Chapingo Autonomous University (km 18.5 of the Texcoco-Lechería highway, Texcoco, State of Mexico, at an altitude of 2,278 m, 19° 29' 13.7'' N and 98° 53' 48.0'' W). According to García (2004), the climate is sub-humid temperate with summer rains (C(wo)(w)b(i').

Sixty, 37-week-old hens were used [30 Rhode Island Red (RIR) and 30 Barred Plymouth Rock (BPR)] with an average weight of 2536±39 g. The birds were managed in a cage-free system: 15 h of confinement every 24 h (6:00 pm to 9:00 am) and 9 h of free access to a white clover paddock (*Trifolium repens* L.) every 24 h (9:00 am to 6:00 pm). During confinement, the hens were kept in an ambient-temperature poultry house with lateral curtains. The interior of the poultry house had eight 1.8 m^2 pens, with wood chip beds. Each pen had an automatic bell water dispenser (15 cm $bird^{-1}$), a hopper feeder (13 cm $bird^{-1}$), and nesting boxes (4 birds $nest^{-1}$). For the grazing period, the white clover paddock (established one year prior) was divided into sub-paddocks (SP) with a 1.2 m high plastic mesh and held 7 to 8 birds, considering 5 m^2 of meadow per animal. Each SP had a 5 L barrel-type water dispenser that was refilled with fresh water every 3 h. Every SP also had a usage period of 7 d, after which new SP were enabled, allowing a resting period of 21 d for every recently-used meadow area. The hens received 150 g of feed $bird^{-1}$ d^{-1}, divided in two rations of 75 g each. The water was offered *ad libitum*. The birds were subject to a lighting program of 16 h light: 8 h darkness.

Treatments and Data

Two treatments were evaluated: COM, 150 g of commercial feed $bird^{-1}$ d^{-1}, and CAS, 150 g of homemade feed $bird^{-1}$ d^{-1}. The 60 birds were randomized to form eight experimental units, which were randomly assigned one of the two treatments. The randomization was restricted so that each genotype (RIR and BPR) was equally represented among the treatments (15 birds of each genotype per treatment) and replicates. Therefore, each treatment had four replicates (two replicates of seven and two replicates of eight birds each, totaling 30 birds per treatment). According to factory values, the composition of commercial feed for adult laying hens (brand GRANJERO, CONCENTRA Consorcio Agroindustrial, S.A. de C.V., Hidalgo, Mexico), was the following: 14% minimum protein, 2% minimum fat, 5% maximum fiber, 12% maximum ash, 12% maximum moisture, 55% nitrogen-free extract.

The homemade concentrate was made based on the PESA recommendations (PESA, 2007). The composition

(%) of the concentrate was the following: ground corn (80.000), toasted and ground black bean (15.000), dehydrated guaje (*Leucaena leucocephala*) leaves (3.333), ground and toasted egg shell (0.833), sugar (0.500), and common salt (0.334). Based on these proportions and information from the literature (Mateos and Sell, 1980; Ravindran and Blair, 1992; NRC, 1994; Teguia and Fru, 2007; Hassan 2015), the nutritional composition of the homemade concentrate was estimated: 3220 kcal of metabolizable energy (ME) kg of feed^{-1}, 11% of crude protein (CP), 0.49% of lysine and 0.18% of methionine. All the eggs from each replicate and treatment were collected daily (11:00 am, 3:00 pm and 6:00 pm) to determine the values of the following variables: egg production (EP, %), egg weight (EW, g), and egg mass (EM, g bird^{-1} d^{-1}). In each replicate, the EP was calculated by dividing the number of eggs between the number of hens in the production day, and the quotient was multiplied by 100. The EW was determined, in the laying day, by individually weighing each egg in an OHAUS scale with a maximum capacity of 15 kg and a resolution of 0.001 kg (RC31P15 model, USA), and later calculating the average per replicate. Finally, the EM was estimated by multiplying the EP by the corresponding EW. Once the data for variables per production day were obtained, weekly values were then estimated.

The EP, EW and EM data were analyzed under a randomly experimental design with repeated measurements, using the SAS V.9.3 MIXED procedure (SAS, 2011). The differences between treatments were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Table 1 shows means of variables associated with the productive performance of hens from 37 to 47 weeks of age. The EP varied from 61.6 to 68.7% in birds with the COM treatment, while hens from the CAS group showed values of 43.6 to 71.3% during the study period. The EP was different between treatments ($P<0.05$) in the last four weeks of observation, the birds in the COM treatment laid 17 to 24% more than the CAS birds.

In 11 weeks of study, the weight of eggs produced by the COM group hens (59.1 to 60.7 g) was greater ($P<0.05$) than that of the hens that received the homemade feed (55.0 to 57.0 g). In the end, the type of feed given to the hens had an effect on the EM of the second half of the study period and lower values were observed ($P<0.05$) in the flocks with the CAS treatment (24.7 to 31.8 g bird^{-1} d^{-1}) compared to the COM group (39.7 to 41.8 g bird^{-1} d^{-1}). Nevertheless, even in the weeks when the differences were not significant ($P \geq 0.05$), the birds fed with the homemade concentrate tended to have a lower EM.

When the hens were fed with homemade feed, recommended by an official agency, the flock produced fewer eggs and with lower weight, compared to birds fed with commercial feed, and thus the daily productivity per bird was also reduced. The birds with the CAS treatment tended to have a lower EP 27.3% of the experiment time. In addition, this disadvantage, when compared to the hens treated with COM was significant in 36.4% of the study period. The lowest EP in the hens treated with CAS coincides with the findings by Aganga *et al*. (2003) and Cahuec-Maas (2017), who observed that non-industrial birds fed with homemade feed (13.5 and 11% CP, respectively) reached only 20 and 86% of the production observed in birds that received commercial feed, for each case. In contrast, Mutayoba *et al*. (2012) did not find differences in the number of eggs produced when local birds were fed with commercial feed (14.6% CP/2604 kcal EM kg^{-1}) or homemade feed (15.5 %

Table 1. Adjusted means of variables associated with productive performance of Rhode Island Red and Barred Plymouth Rock hens, in a cage-free system and fed two types of feed [commercial (COM) or homemade (CAS)].

Age (weeks)	% Egg production†		Egg weight (g)‡		Egg mass (g hen^{-1} d^{-1})§	
	COM	CAS	COM	CAS	COM	CAS
37	67.9	71.3	59.1^{a}	56.2^{b}	40.2	40.1
38	63.4	66.9	59.8^{a}	55.0^{b}	38.1	36.8
39	64.8	68.1	60.1^{a}	56.5^{b}	39.1	38.5
40	65.3	57.3	60.1^{a}	56.8^{b}	39.3	32.5
41	61.9	53.0	60.3^{a}	56.4^{b}	37.4	29.9
42	65.4	56.0	60.6^{a}	56.7^{b}	39.7^{a}	31.8^{b}
43	61.6	61.6	60.6^{a}	56.7^{b}	37.3	34.9
44	68.7^{a}	50.9^{b}	60.7^{a}	57.0^{b}	41.8^{a}	29.2^{b}
45	67.1^{a}	50.1^{b}	60.2^{a}	56.2^{b}	40.3^{a}	28.3^{b}
46	67.9^{a}	43.6^{b}	60.5^{a}	56.5^{b}	41.1^{a}	24.7^{b}
47	66.4^{a}	48.9^{b}	60.7^{a}	55.9^{b}	40.3^{a}	27.4^{b}

†SE = 4.7; ‡SE = 0.6; §SE = 2.8. a, b Means of each productive variable, with different letter within each row, are significantly different ($P<0.05$). SE = standard error of the mean.

CP/3620 kcal EM kg^{-1}). A balanced diet is requisite for an optimal productive performance in hens (Ravindran, 2013b). The commercial feeds are formulated with precision so that they contain the quantity of nutrients that meets the birds' needs (Chadd, 2008). Based on the estimated nutritional content of the homemade concentrate evaluated in this study, this feed differs from reference values (NRC, 1994) in terms of EM, CP, lysine, and methionine. In particular, the concentrations of the last three nutrients were less than those recommended. Lysine and methionine are two essential amino acids for birds and a marginal deficiency in them decreases egg production (Cuca-García *et al*., 2016), which explains the results observed in the EP variable.

The eggs produced by the hens fed homemade feed weighed less than the eggs from the hens fed with the commercial feed, and this difference between treatments varied from 4.9 to 8.0%. This result agrees with what was reported by Aganga *et al*. (2003), who observed that the eggs of local hens fed with homemade feed (13.5% CP) were 5% lighter than those produced by birds fed with commercial feed (16.0% CP). Authors like Mutayoba *et al.* (2012) did not find differences in egg weight (38.9 to 39.3 g) of local hens fed with commercial feed (14.6% CP/2604 kcal EM kg^{-1}) or homemade feed (15.5 % CP/3620 kcal EM kg^{-1}). As indicated, the homemade feed evaluated in the present study was found to be deficient in terms of CP, lysine, and methionine. The results observed in terms of EW can be explained by feed composition (Cuca-García *et al*., 2016), thus the amino acid content of the CAS diet was considered to be lower for protein synthesis in the magnum (Penz and Jensen, 1991; Gomez and Angeles, 2009; Silva *et al*., 2015).

During the entire evaluation period, the EM of birds with homemade feed was numerically lower when compared to the birds that received commercial feed. This difference was significant during 45.5% of the trial time. There is no precedent for evaluation of EM with homemade feeds; however, experiments with commercial birds have shown that the increase in EM occurs when increasing amounts of essential amino acids are administered in the diet (Gómez and Ángeles, 2009; Bonekamp *et al.*, 2010). The lowest EM observed in the CAS treatment is explained by the afore-mentioned deficiency in CP, lysine, and methionine, and the function of these nutrients in the EP and the EW (Cuca-García *et al*., 2016).

Based on the results obtained, it is necessary to design homemade feeds that consider the nutritional requirements of the birds and the nutritional characteristics of the ingredients to be used. Likewise, and before being recommended for their use, the feeds need to be systematically evaluated in order to know their effect in the productive performance of birds.

CONCLUSIONS

The use of homemade feed based on corn, toasted and ground black bean, guaje leaves flour, toasted and ground eggshells, sugar, and common salt, reduced the productive performance of hens in a cage-free system, in terms of egg production, egg weight, and egg mass, when compared to the use of a commercial feed.

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