Characterization and quantification of waste from laying hens fed with different corn particle size

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SUMMARY

This work was developed aiming at evaluating the effect of different corn grains milling grades under the characterisation and quantification of laying hens' waste. For this, 128 Hisex Brown strain 30 weeks old hens (laying hens) were used, in a period of time of 112 days (4 cycles of 28 days). The hens were distributed in a completely randomized experimental design, with four treatments, four replicates and eight hens per each experimental unit. The treatments consisted of four diets with different milling diameters (mm): 2.0 (average geometrical diameter AGD= 565 µm); 4.0 (AGD= 620 µm), 6.0 (AGD= 781 µm), and 8.0 (AGD= 1085 µm). The variables analyzed were: waste production (kg·hen.day-1), dry matter (kg and %), percentages of phosphorus and nitrogen, and residue coefficient (kg). The results were submitted to analysis of polynomial regression (p<0.05). The waste production, the residue coefficient (kg) and the phosphorus amount (%) in the laying hens waste are not influenced by the corn particle size (average geometrical diameter from 565 to 1085 µm). However, the size of corn particles changes the waste composition, in a way that the higher the particle size, the smaller the dry matter amounts (% and kg) and also the higher the nitrogen amount.

ADDITIONAL KEYWORDS

AGD.
Dry matter.
Nitrogen.
Phosphorus.
Residue coefficient.

Caracterização e quantificação de dejetos de poedeiras alimentadas com milho de diferentes granulometrias

RESUMO

Este trabalho foi desenvolvido com o objetivo de avaliar os efeitos de diferentes graus de moagem do milho sobre a caracterização e quantificação dos dejetos de poedeiras semipesadas. Para isso, foram utilizadas 128 aves da linhagem Hisex Brown (poedeiras semipesadas) com 30 semanas de idade, durante o período de 112 dias (quatro ciclos de 28 dias). As aves foram distribuídas em um delineamento experimental inteiramente casualizado, com quatro tratamentos, quatro repetições e oito aves por unidade experimental. Os tratamentos consistiram de quatro rações com diferentes graus de moagem (mm): 2,0 (diâmetro geométrico médio - DGM= 565 µm); 4,0 (DGM= 620 µm); 6,0 (DGM= 781 µm) e 8,0 (DGM= 1085 µm). As variáveis analisadas foram: produção de dejetos (kg.ave.dia-1), matéria seca (kg e %), porcentagens de fósforo e nitrogênio nos dejetos, e coeficiente de resíduo (kg). Os dados foram submetidos à análise de regressão polinomial (p<0,05). A produção de dejetos, o coeficiente de resíduo (kg) e o teor de fósforo (%) dos dejetos de poedeiras não são influenciados pela granulometria do milho (DGM de 565 a 1085 µm). No entanto, o tamanho das partículas do milho altera a composição dos dejetos, de forma que o aumento da granulometria resulta em menores teores de matéria seca (% e kg) e maiores teores de nitrogênio (%).

PALAVRAS CHAVE ADICIONAIS

DGM.
Matéria seca.
Nitrogênio.
Fósforo.
Coeficiente de resíduo.

INFORMATION

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INTRODUCTION

The poultry intensive creation systems generate big amounts of waste, being a concern when we talk about environmental preservation. The environmental impact minimization of animal production is intrinsically related to the maximum of food nutritive potential utilization offered to the animal, where the composition and digestibility knowledge of the nutrients has to be considered as well the feed ingredients, the animal nutritional requirement, and also the nutritional additives to a better diet nutritional balancing to feed the breeding stocks' production (Pereira *et al.*, 2010).

Several factors can influence the chemical composition of the waste of laying hens and, among them, can be cited the age of hens, feeding composition, feces stock facility ventilation, management of the hens, feeder and drinker systems, season, and yet, the stocking time. The waste have substantial levels of nitrogen, phosphorus, cupper, and zinc, elements that have contributed to the environmental pollution increasing. Therefore, the nutritional strategies to minimize these potentially pollutants waste to the environment have been one of the higher concern of the professionals involved with the poultry sector (Ferket *et al.*, 2002).

The amount of nutrients and odors launched to the environment, associated to the poultry production, can be changed through nutritional strategies, which the practical application is dependent on the costs as well the possible biological limitations.

This nutritional manipulation can occur through enzymes in the feeding (phytase), more balanced diets (using the ideal protein concept), and high bioavailability ingredients (organic-like minerals), in order to improve the nutrients in the feed utilization efficiency by the hens (Nahm, 2002).

To standardize the ingredients in a feed, ensuring the availability of all nutrients to the animals, the cereal grains are milled focusing increase the contact surface, thus, improving the digestive enzymes action on its nutrients (Zanotto *et al.*, 1995). Nutritionally, the particle size in the ingredients focused to the feed production can influence the digestibility and the higher the retention time, the higher the nutrient uptake, thereby influencing their excretion to the environment.

An important industrial poultry aspect is the implantation of total quality control, which drives the sector to evaluate the aspects related to the environmental impact that the this activity accumulation residue can generate and also, find ways to use these residues within the poultry activity itself or even outside it. This way this work was developed aiming evaluate the effect of different corn grains milling grades under the characterization and quantification of waste of laying hens.

MATERIAL AND METHODS

The experiment was conducted in the municipality of Aquidauana. Geographically, the region is located between the coordinates 20º 28'S latitude and 55º 48' W longitude, at an altitude of 174 meters. For this, 128 hens of Hisex Brown strain (laying hens) of 30 weeks old were used, in a period of time of 112 days (4 cycles of 28 days). The hens were housed in pairs, in galvanized wire cages with four divisions of 25 (high) x 40 x 45 cm, in a conventional laying shed covered with asbestos cement fiber tiles.

The drinker used was the channel-like with water flowing all over the frontal extension of the cages. Feeders were placed under the drinkers, one to each experimental unit. The drinkers were cleaned daily and the feed was provided *ad libitum* at 08:00 h and 16:00 h. The lighting program used was the 17:00 h a day one (natural + artificial lighting).

The aviary thermal conditions were checked during all experimental period through the environmental temperature (maximum and minimal), as well the relative humidity, being them, respectively, 23.6ºC, 19.3ºC, and 75%.

The hens were distributed in a completely randomized experimental design, with four treatments, four replicates and eight hens per each experimental unit.

The treatments were four diets formulated from a single lot corn grains, fractionated into four parts, each part submitted to a different milling diameters (mm) as follow: 2.0 (average geometrical diameter - AGD= 565 µm); 4.0 (AGD= 620 µm); 6.0 (AGD= 781 µm); and 8.0 (AGD= 1085 µm). Four experimental diets were formulated, one to each corn fraction. The experimental diets **(table I)** were formulated according to the strain demands, using the chemical composition data and the food energetic values, according to Rostagno *et al.* (2005). To mill the corn, a hammer crusher was used (28 hammers), driven by a 20HP engine, 3500 rpm. The food and diets particle size was determined according to methodology described by Zanotto and Bellaver (1996).

To quantify the waste production by the hens, weighing and collecting were done three times per week. Plastic bags were put under the cages in order to collect the waste. After 24 hours, the plastic bags were removed and weighed to obtain data about the natural matter waste production, removing from it the samples to characterize the waste.

The samples were dried at 65°C, up to constant weigh. Part of the dried waste was dried at 105°C to obtain the dry matter (DM). To determine the residual coefficient (Rc) was followed the methodology des-

Table I. Percentage and calculated composition of the experimental diets (Composições percentual e calculada das rações experimentais).

Ingredients, %	
Corn	61.52
Soybean meal (45%)	26.12
Limestone	7.05
Dicalcium phosphate	0.32
Vegetable oil	0.90
DL-methionine, 99%	0.08
Core[1]	4.00
BHT	0.01
TOTAL	100.00
Calculated values	
Metabolizable energy (Kcal/kg)	2.780
Crude protein (%)	17.20
Methionine + cystine (%)	0.69
Lysine (%)	0.88
Calcium (%)	3.80
Available phosphorus (%)	0.45

[1]Composition per kg of product: Cu 182.88 mg; Fe 888.42 mg; I 15.25 mg; Mn 1 183.20 mg; Se 7.65 mg; Zn 918.76 mg; Antioxidant 0.10 g; Vitamin A 176 250.00 IU; Vitamin D_3 42 562.50 IU; Vitamin E 131.25 mg; Vitamin B_1 25.46 mg; Vitamin B_2 57.00 mg; Vitamin B_6 31.54 mg; Vitamin B_{12} 152.00 µg; Vitamin K 30.00 mg; Nicothenic acid 380.00 mg; d-calciumpantothenic acid 152.00 mg; Methionine 14.35 g; Choline choride 3.75 g; Ca 228.12 g; F 73.15 g; Na 38.70 g; F (Máx.) 731.50 mg; Vehicle q.s.p. 1000 g.

cribed by Santos *et al.* (1999), where it was calculated based on the total amount of waste produced (dry basis) related to the eggs production, determined in mass (kg).

The waste composition was determined based on the dry matter percentage. The N amount was determined according methodology described by Silva and Queiroz (2005). The P amount was determined by the colorimetric method using the spectrophotometer. The analytical procedure was the nitri-perchloric acid digestion of the samples and subsequent ammonium vanadate and ammonium molybdate mixture in the extract to develop color, according to Malavolta *et al.* (1989) methodology.

The results were submitted to analysis of variance and polynomial regression analysis through the least square method. Differences between averages were obtained using the Tukey Test ($p<0.05$).

RESULTS AND DISCUSSION

The medium results regarding to waste production and composition, as well the residue coefficient according to the different corn milling are in the **table II**.

Through the regression analysis was verified that the higher the corn particle size, the smaller, linearly ($p<0.05$), the laying hens waste dry matter (% and kg) **(table II)**. This result is related, probably, to the food bolus longer transit when the feed had bigger corn particles, providing a higher digestibility and nutrients absorption due to the longer contact between secretions and absorptive cells, minimizing the excretion.

Carlos and Edwards (1997), Yasar (2003), Kilburn and Edwards Jr *et al.* (2004), Amerah *et al.* (2007) and Xu *et al.* (2015) in studies with broilers reported that the increase of the particles improves the digestibility of the protein due to the better control of the intestinal transit time by emptying the gizzard. Nir *et al.* (1994), Nir *et al.* (1995) and Parsons *et al.* (2006) suggest that the degradation of the particles in the proximal small intestine is slower when feed particles are larger, therefore, increases peristalsis, which may lead to a higher nutrient digestibility.

Higher DM values in laying hens waste were found in works done by Santos *et al.* (1999) (20.84 to 30.85%), by Quiroga *et al.* (2010) (25.47%), and by Dekker *et al.* (2011) (23.80%). Among other factors, the waste DM can vary according to the food offered to the animals, the water consumption, the waste management, and the environmental conditions.

The N percentage determined in the laying hen waste had a regression effect ($p<0.05$) characterized by the quadratic behavior according to the particle size increase (maximum point at 921.5 µm) **(table II)**.

When N amount in waste was evaluated, not only the specific endogenous losing (the lose that is dependent to the diet) should be considered, but also the basal endogenous losing (lose that is independent to the diet), related to the animal metabolic state. Endogenous loses consist mainly digestible enzymes, mucoproteins, desquamations of enterocytes and albumin (Moughan and Schuttert, 1991; Ribeiro, 2009). The higher N excretion observed when the diameter of particles was bigger may have been influenced by the higher particle size in the gastrointestinal tract.

The average N amount in the laying hen waste found in this work are superior than the ones found in other works, which values vary from 2.8 to 5.98% (Kiehl, 1985; Schepers and Mosier, 1991; El Boushy and Van Der Poel, 1994; Leeson *et al.*, 2000; Quiroga *et al.*, 2010; Dekker *et al.*, 2011). On the other hand, Augusto (2007) evaluating different production systems, observed that automatic and conventional (one-day storing) systems presented, respectively, 6.68 and 7.40% of N in the laying hens waste, confirming this work data.

However, higher or lower N loses can be seen due factors like different diet provided to the animals and waste managing and storing, making important these observances. Usually hens have high protein diets

Table II. Production and composition of waste and residue coefficient (Rc) in laying hens fed on different particle size corn (AGD) (Produção e composição dos dejetos e coeficiente de resíduo (Cr) de poedeiras semipesadas alimentadas com milho de diferentes granulometrias (DGM).

AGD (µm)	Waste (kg · hen · day^{-1})	Dry matter (%)	Dry matter (kg)	Rc (kg)	Phosphorus (% DM)	Nitrogen (% DM)
565	0.132	21.84^{a}	0.029	0.441	3.42^{ab}	7.17^{b}
620	0.142	21.10^{ab}	0.030	0.474	3.78^{a}	7.86^{a}
781	0.136	20.51^{ab}	0.028	0.492	3.30^{b}	8.19^{a}
1085	0.135	19.58^{b}	0.027	0.517	3.58^{ab}	8.23^{a}
Means	0.136	20.76	0.028	0.481	3.52	7.86
SEM	0.002	0.298	0.001	0.014	0.061	0.124
CV (%)	6.94	4.47	6.36	11.33	5.08	3.32
Regression	NS	Linear	Linear	NS	NS	Quadratic

[a,b]Means in the same column followed by different letters differ from each other by Tukey test ($p<0.05$); SEM= standard error of the mean; CV= coefficient of variation; NS= not significant.
Dry matter (%): $Y=23.77-0.00395*X$, $R^2=0.94$;
Dry matter (kg): $Y=0.0329-0.0000059*X$, $R^2=0.85$;
Nitrogen (%): $Y=0.953+0.0162*X-0.00000879*X^2$, $R^2=0.89$.

when related to other animals. This way, it can be considered a high potential N pollutant activity.

We did not observe effect between the evaluated corn particle sizes (p>0.05) under the waste production, Rc (kg) and P (%) amounts.

The amount of waste produced by the hens verified in this work is close to the amount described by Coelho and Verlengia (1973), by Moreng and Avens (1990), by El Boushy and Van Der Poel (1994) and by Leeson *et al.* (2000), they found a production of 0.12, 0.11, 0.12 and 0.10 of waste kg hen day^{-1}, respectively.

The average data found to P percentage corroborate with Leeson *et al.* (2000), where the laying eggs waste may present about 4.2% of P in its composition. However, Santos *et al.* (1999) and Augusto (2007) found different average concentrations when they worked with laying hens, being 1.54% (manure) and 2.01% (waste), respectively. Equally, concentrations smaller than we found in this work were seen by Quiroga *et al.* (2010) and Dekker *et al.* (2011), 0.65 and 1.34% respectively.

According to Ao *et al.* (2007), high P amount found in hen waste is generally due to the high inorganic P sources add into the diet to fulfill the bird's demand, once the vegetal-origin products, the most part of its composition, present an availability of 33.3%, having 67% unavailable because of inositol bonds, generating the fhytic acid molecule, that originates organic complexes with amino acids, proteins, and nutritionally important minerals like calcium, zinc, manganese, cupper, and iron.

Differences observed between the works probably are due how easy these chemical elements in the waste are used by microorganisms during the decomposition and also how easily N is volatilized as ammonia. Besides, data related to laying hens waste and intrinsic nutrients rarely evidence if they are expressed in the natural matter (NM) or in the dry matter (DM), with a lack of information about how long these waste are kept stored in the cages until its evaluation, resulting in different results to the same nutrient.

The waste production, the residue coefficient (kg) and the phosphorus amount (%) in the laying hens waste are not influenced by the corn particle size (average geometrical diameter from 565 to 1085 µm). However, the size of corn particles changes the waste composition, in a way that the higher the particle size, the smaller the dry matter amounts (% and kg) and also the higher the nitrogen amount (%).

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