Ciência Rural, Santa Maria, v.48:10, e20170686, 2018 http://dx.doi.org/10.1590/0103-8478cr20170686

ISSNe 1678-4596
ANIMAL PRODUCTION

Feed selectivity of laying hens undergoing different beak trimming in two rearing systems

Rafael Alan Baggio[1] Samuel Jacinto Lunardi[2] Manuela Testa[1] Diego Mateus Chiossi[2] Tiago Goulart Petroli[3] Marcel Manente Boiago[1] Diovani Paiano[1] Maria Luisa Appendino Nunes Zotti[1*]

[1]Programa de Pós-graduação em Zootecnia (PPGZOO), Universidade do Estado de Santa Catarina (UDESC), Campus UDESC Oeste, Rua Beloni Trombeta Zanin, 680E, Bairro Santo Antônio, 89.815-630. Chapecó, SC, Brasil E-mail: maria.anunes@udesc.br. * Corresponding author.
[2]Curso de Zootecnia, Universidade do Estado de Santa Catarina (UDESC), Campus UDESC Oeste, Chapecó, SC, Brasil.
[3]Curso de Zootecnia, Universidade do Oeste de Santa Catarina (UNOESC), Xanxerê, SC, Brasil..

ABSTRACT: *The present research was conducted to evaluate whether different beak trimming methods and rearing systems affected the feed selectivity of laying hens. A total of 178 Hy-line Brown laying hens in the growing phase and 120 hens in the production phase were divided in a factorial arrangement (2 x 3), with two rearing systems (floor and cages) and three beak trimming methods: without beak trimming (control), hot-blade beak trimming, and infrared beak trimming, with four replicates. Laying hens were feed with isonutritive diets. Samples were collected from feed orts and feed provided, with a subsequent analysis of dry matter, crude energy, crude protein, mineral matter, geometric mean diameter and geometric standard deviation. The results were subjected to the error normality test, analysis of variance and the Fisher-Snedecor (P<0.05) and Duncan tests (P<0.05). The beak trimming methods evaluated were not sufficient to prevent feed selection in laying hens. However, in the growing phase, hot-blade beak trimming reduced feed selection capacity of laying hens more than did infrared beak trimming. The cage system favored feed selection, both in the growing and production phases.*
Key words: *animal welfare, cage-free, feed selection.*

Seletividade alimentar de galinhas poedeiras submetidas a diferentes métodos de debicagem em dois sistemas de criação

RESUMO: *O presente trabalho foi conduzido para avaliar se diferentes métodos de debicagem e sistemas de criação afetam a seletividade alimentar de galinhas poedeiras. Foram utilizadas 178 aves na fase de recria e 120 aves na fase de produção, da linhagem Hy-line Brown, divididas em um delineamento experimental em esquema fatorial (2x3), com dois sistemas de criação (piso e gaiolas) e três manejos de bico: sem debicar (controle), debicagem por lâmina quente e radiação infravermelha, com quatro repetições. As aves foram alimentadas com rações isonutritivas e foram coletadas amostras das sobras e das rações controle, com posterior análise da matéria seca, energia bruta, proteína bruta, matéria mineral, diâmetro geométrico médio e desvio padrão geométrico. Os resultados foram submetidos ao teste de normalidade dos erros, análise de variância e aos testes de médias de Fisher-snedecor (P<0,05) e Duncan (P<0,05). Os métodos de debicagem avaliados não são suficientes para impedir a seleção de alimento de galinhas de postura. No entanto, na fase de recria, a debicagem por lâmina quente reduz a capacidade de seleção das galinhas, em relação à debicagem por infravermelho. O sistema de criação em gaiolas favorece a seleção de alimento pelas galinhas poedeiras, tanto na fase de recria quanto na fase de produção.*
Palavras-chave: *bem-estar animal, cage free, seleção de ração.*

INTRODUCTION

Birds use their beaks for a variety of functions, including hatching, feed selection and intake, as well as for defense and attack. However, in commercial production systems, some of these functionalities need to be inhibited, since it is undesirable for the bird to select feed or peck eggs and/or other birds. Therefore, widespread beak trimming is recommended (KUENZEL, 2007), particularly for intensive production systems.

Among the methodologies used for beak trimming, we focused on hot-blade and infrared trimming (VIEIRA FILHO et al., 2016). Hot-blade trimming is a fully manual process performed up to the tenth day of life with a guillotine blade heated to approximately 750°C.

Received 09.26.17 Approved 08.24.18 Returned by the author 09.14.18
CR-2017-0686.R3

The blade simultaneously cuts and cauterizes the beak (JENDRAL & ROBINSON, 2004).

The hot-blade method is most often employed, having good efficiency in reducing cannibalism. However, the practice involves mutilation of the beak, and pain involved is a concern of welfare-related entities. It is believed that the procedure leads to formation of neuromas, which could also cause pain to the animal (DENNIS & CHENG, 2010).

By contrast, infrared radiation trimming is performed on the bird's first day of life in the hatchery, using a high intensity laser that penetrates through the horny layer and prevents growth of the germinative layer. After treatment, the corneal layer remains intact until seven to ten days after the cut, at which point the tip of the nozzle begins to fall apart (MARCHANT-FORDE et al., 2008).

The production system in which the animals are maintained also has an important influence on the behavior and performance of the birds. In cages, the birds are subjected to a smaller, less rich environment. This provides worse welfare compared to bed and nest floors (CARVALHO et al., 2017). In addition, the feed supply methodology in the two breeding systems differs: a tubular feeder is normally used in the floor systems, while in cages a trough-type feeder is used, providing a smaller amount of food.

In our literature survey; although, beak trimming was carried out with the assumption of decreasing feed selectivity, we found no studies that quantified the effects of various beak trimming methods and their interaction with the breeding system on feed selectivity. Thus, the objective of this research was to evaluate whether different methods of beak trimming and breeding systems affected feed selectivity in laying hens.

MATERIALS AND METHODS

Two sequential experiments were carried out in the growing (14 and 16 weeks) and production phases (18 and 20 weeks). Experiments were carried out between July 2016 and January 2017. An experimental facility (located at 27º07'S; 52º37'O; elevation 680m) had a total area of 32m², built with wooden sides, a concrete floor, fiber cement roofing tiles, ceiling height of 2.5m, and external partitions of 1m. The shed was equipped with plastic curtains on the sides to control the thermal environment.

Animals and experimental units

The experiments were carried out during the growing and production phases of commercial laying hens (Hy-line Brown). A total of 144 birds were used in the growing phase and 120 birds were used in the production phase. In order to simulate a floor system, 12 boxes (1 x 1 x 1m) were built, equipped with a tubular type feeder, a pendulum-type drinking fountain and a pine litter with a depth of 0.1m. The cage rearing system consisted of a set of 12 cages (0.5 x 0.6 x 0.4m) equipped with a trough-type feeder and cup-type drinker, positioned in front and at the bottom of the cages, respectively.

The number of birds per cage was adjusted over the experimental period in order to achieve animal density prescribed by the lineage manual (HY-LINE, 2014). In the growing phase, 10 birds per box and seven birds per cage were used. In the production phase, there were five birds in each box and five birds in each cage.

Experimental design

We used factorial design (2 x 3), with two rearing systems (floor or cages) and three methods of beak trimming (hot-blade, infrared and undercutting, the latter serving as the control treatment). There were a total of six treatments, with four replicates, in 12 experimental units for each rearing system and 24 experimental units in total, for each of the experiments/phases studied.

Beak trimming methods

Hot-blade trimming was carried out by a trained individual, using a commercial beak trimmer (no. 950-08, Uniquímica, Brazil) on the birds'12th day of life, with revision in the 12th week of life, in order to repair uneven beak growth. We opted to perform trimming revision to model the experimental conditions to actual methods performed in the field. Infrared irradiation was performed on the birds' first day of life in the hatchery with the Poultry Service Processor®/Nova Tech Engenharia.

Feed selectivity

Identical diets were used for all treatments, differing only for the growing and production. These were adjusted according to the nutritional requirements proposed by ROSTAGNO et al. (2011). Feeds were made from locally sourced ingredients with corn previously milled in a 5mm sieve mesh and mixed in a Y-type mixer for 11 minutes (Model MA201/5MO, Marconi, Brazil).

The collections were carried out on the first days of weeks 14 and 16 (growing phase) and 18 and 20 (production phase). Samples from the two weeks of each phase formed a composite sample for the analysis. Samples were collected from feed provided and feed orts from the feeders that were then analyzed, and the values obtained from the feed orts were compared in order to estimate the birds' feed selectivity with respect to ingredients.

For the days of collection, the amount of feed supplied was calculated based on the number of animals in each experimental unit: the intake of each bird was calculated in one hour/light and increased by 10% (correction for possible waste). The value obtained (estimated intake per hour + 10%) was multiplied by two in order to allow orts in the feeders in sufficient quantity to compose the sample for the analysis.

The methodology used for the feed orts collect collection required adjustments for each treatment according to the rearing system using different feeders (trough-type in the cages and tubular-type on the floor). In the cages, feed was provided and feed orts collected at one-hour intervals. In the floor system, feed was supplied and feed orts collected every two hours. This methodology was adopted by conducting tests prior to the execution of the experiment to allow two rearing systems to have enough feed orts for sampling.

Laboratory analysis

Feed samples and orts were subjected to analysis of dry matter (DM), mineral matter (MM), crude protein (CP) (SILVA & QUEIROZ, 2002) and crude energy (CE) with calorimeter (Model C200, IKA). Physical analysis of the mean geometric diameter (MGD) and the geometric standard deviation (GSD) was performed according to the methodology proposed by HANDERSON & PERRY (1955). Calculations were made using Granucalc software (2012).

Statistical analysis

The data were previously subjected to the Shapiro-Wilk test (P>0.05) to verify the normality of the errors, and were transformed if necessary. Subsequently, a variance analysis was performed, in which the effects of the rearing system, the beak trimming method and the respective interactions were tested. It was accepted as different when $P<0.05$ by the F test and, when necessary, the Tukey test ($P<0.05$). Subsequently, in addition to analysis of variance, the confidence intervals (CI) of the means (95%) were calculated in order to compare the amplitude of the CI of the orts composition with the initial values of the feed.

RESULTS AND DISCUSSION

Exp. I – Growing phase

There was no interaction for any of the variables (Table 1) and the beak trimming methods did not influence the variables evaluated (P>0.05).

Table 1 - Chemical, physical and energetic composition of feed orts (± confidence intervals) of laying hens subjected to different beak trimming methods and rearing systems in growing phase.

	----------Evaluated variables[1]----------					
	DM, %	MM, %	CP, %	CE, kcal/kg	MGD, µm	GSD
	----------Breeding system----------					
Floor	90.09±0.22a	6.29±0.15a	18.82±0.26	3962.6±19.9a	562.17±15.53	2.18±0.05
Cage	89.71±0.11b*	5.87±0.15b	18.87±0.16	3873.4±9.1b	539.33±16.03	2.20±0.04
	----------Beak trimming method----------					
Infrared	89.98±0.30	6.18±0.24	19.06±0.27	3902.0±23.6*	540.13±19.14	2.18±0.05
Hot Blade	89.67±0.12*	5.84±0.19	18.57±0.36	3927.9±37.1*	573.38±10.00	2.21±0.04
Control	90.05±0.18	6.22±0.23	18.90±0.15	3924.1±32.9*	538.75±23.04	2.19±0.06
	----------P values----------					
Systems	0.01	0.01	0.81	<0.01	0.08	0.66
Methods	0.11	0.11	0.18	0.34	0.09	0.65
Syst*Met.	0.52	0.69	0.22	0.50	0.35	0.58

[1]Dry matter (DM), mineral matter (MM), Crude protein (CP), Crude energy (CE), mean geometric diameter (MGD) and geometric standard deviation (GSD); *Values followed by an asterisk are similar to the initial composition of the feed. Averages followed by different lowercase letters in the column differ significantly by the F test ($P<0.05$).

The floor system gave higher ($P<0.05$) mean DM, MM and there was a trend towards increased MGD (P = 0.08) when orts were compared to each other.

The lack of significant interaction in the growing phase was not expected, because in less rich environments such as cage system, animals with an intact beak would tend to select the feed provided. Another factor to be considered that may have contributed to the absence of interactions in this phase was the growing feed. This feed had a lower MGD than that of the production phase, and may have minimized selection behavior within the time evaluated in the experiment.

The amplitudes of the confidence intervals indicated similarity of the DM values of orts and feed provided in the cage system and when hot blade beak trimming method was used (Table 1). Likewise, the amplitudes of the confidence intervals of all the beak trimming methods showed no difference between the CE values of feed provided and orts. Conversely, the amplitudes of the confidence intervals for the other averages did not include the values of the feed provided in the growing phase, suggesting that for variables MM, CP, MGD and GSD there was a difference in the characteristics of the feed provided and orts.

We expected that the un-trimmed birds would show a difference in orts compared to the trimmed groups, since one of the main arguments for the beak trimming is the limitation of the selection capacity for the feed ingredients (PRESCOTT & BONSER, 2004). However, we did not observe this phenomenon in the growing phase. Nevertheless, the amplitude of the confidence intervals showed that the hot-blade trimming method provided similar DM values of the orts in relation to the feed provided (Table 1), possibly as a result of the lower selection capacity for this treatment. PETROLLI et al. (2017) showed that infrared beak trimming improve feed conversion ratio during growing phase in relation to hot blade beak trimming.

The amplitude of the CI for the CE variable from the orts covered the CE value of the feed provided in the growing phase, suggesting that there was no feed selection for ingredients with higher or lower energy in this phase (Table 1). We believe that this response is explained by the fact that growing feed is composed of ingredients with energy values closer to each other (Table 2). This may have made it impossible to select for higher or lower CE ingredients. Unlike the production phase (Table 3), in which ingredients such as soybean oil, with high energy value and high percentage of ingredients such

Table 2 - Feed composition used in the experiments.

	--Phases evaluated--	
Ingredients, g/kg	Exp. I growing	Exp. II production
Ground corn	672.5	657.0
Soybean meal	205.0	218.0
Wheat bran	91.5	-
Soy oil	-	11.0
Dicalcium phosphate	14.3	15.0
Calcitic limestone	10.5	89.0
Salt	3.8	5.0
Pre-micronutrient mixing	2.0	3.0
DL-methionine	0.4	2.0
Composition analyzed		
Dry matter, % -[1]	89.66	90.73
Mineral matter, % -[1]	4.46	10.76
Crude protein, % -[1]	16.62	16.00
Crude energy, kcal/kg -[1]	3901	3622
Mean geometric diameter, µm -[2]	772.45	968.75
Geometric standard deviation[2]	2.47	2.08

[1]Values analyzed according to methodology described by Henderson & Perry (1965). [2]Values analyzed according to methodology recommended by SILVA & QUEIROZ (2002).

Table 3 - Chemical, physical and energetic composition of feed orts (± confidence interval) of laying hens subjected to different beak trimming methods and laying systems in the production phase.

	--------Evaluated variables[1]--------					
	DM, %	MM, %	CP, %	CE, kcal/kg	MGD, µm	GSD
	--------Breeding system--------					
Floor	90.75±0,16*	11.95±0.26 a	17.71±0.32	3555.5±11.5	794.9±21.8 a	1.85±0.05
Cage	90.97±0.12	13.59±0.85 b	18.11±0.18	3545.7±25.3	730.0±21.0 b	1.78±0.02
	--------Beak trimming method--------					
Infrared	90.85±0.13	13.09±0.79	17.62±0.26	3535.2±21.3	762.6±26.7	1.86±0.04
Blade	90.75±0.24*	13.10±1.16	17.99±0.28	3538.2±19.2	765.6±42.5	1.76±0.08
Control	90.98±0.16*	12.11±0.57	18.12±0.41	3578.0±25.6	759.1±33.5	1.83±0.04
	--------P values--------					
System	0.03	<0.01	0.09	0.58	<0.01	0.17
Methods	0.20	0.22	0.19	0.15	0.87	0.28
Syst*Met.	<0.01	0.28	0.58	0.22	0.49	0.35

[1]Dry matter (DM), mineral matter (MM), Crude protein (CP), Crude energy (CE), Mean geometric diameter (MGD) and geometric standard deviation (GSD); *Values followed by an asterisk are similar to the initial composition of the feed. Averages followed by different lowercase letters in the column differ by the F test (P <0.05).

as calcitic limestone were used. These did not present energy value in their nutritional matrix.

Exp. II - Production

There was interaction (P<0.05) between rearing systems and trimming methods for the DM variable. For the other variables, the interaction was not significant (Table 3). For the growing phase, the trimming methods did not influence the orts characteristics in all variables evaluated at the production phase (P>0.05) (Table 3). However, the floor system resulted in higher MGD and lower MM (P<0.05) of orts (Table 3).

The interaction of the DM showed that, in the floor system, the DM of the orts was higher (P <0.05) in the control treatment (without trimming) in relation to the two trimming methods, which did not present themselves differences. In the cage system, the trimming methods did not affect the DM of orts (P>0.05). For the hot-blade method, birds in the floor system presented lower (P<0.05) DM in orts (Table 4).

In the laying phase, the amplitude of the CI for the unfolded averages DM means of the orts indicated similarity with the DM value of the feed provided to birds raised in the floor and subjected to infrared trimming, as well as for those raised in cages and not trimmed. Under the conditions mentioned (combined-plotted with infrared trimming, as well as cage rearing combined with control treatment), the amplitudes of CIs of the DM variable indicated differences between the feed provided and orts.

Conversely, none of the other variables presented amplitude for the CI that included the average of the initial composition of feed, suggesting that the selection occurred independently of the trimming method.

Results obtained were corroborated by those of BAGGIO et al., (2017) studied laying birds with similar characteristics and did not verify effects of the trimming methods on the performance of the birds in growing phase. This reinforces our hypothesis that the birds had the same effective selection rate; and therefore, the same intake.

Unlike in the growing phase, in the production phase, the dry matter variable showed a significant interaction and a higher value for DM in the control group, in the treatment floor (Table 3). In addition, the control group maintained in the floor system showed mean values more different than the average DM of the feed provided. These expected results were associated with the longer time between collections, considering the characteristics of the feeder type of the floor system (previously described in the methodology) and feed composition of the feed (Table 2). In this phase, there was a high percentage of calcitic limestone of coarse granulometry (8.9%). Combination of these elements may have resulted in significant interaction for the posture phase of the DM

Table 4 - Interaction partitioned for the dry matter composition (average ± confidence interval) of the feed orts of the ration of laying hens submitted to different methods of deboning and laying systems in the production phase.

	--------------------------------Production system--------------------------------		
Trimming method	Floor	Cage	Mean
Infrared	90.66±0.11 a*	91.03±0.11	90.85
Blade	90.43±0.12 aA	91.08±0.12 B	90.75
Control	91.16±0.21 b	90.79±0.21*	90.98
Mean	90.75	90.97	

Means followed by different lowercase letters in the column and different capitals in row differ (P <0.05) by Tukey's test. *Values followed by an asterisk are similar to the initial composition of the feed.

variable. Conversely, in the cage system, the control treatment; although, not differing by Tukey test of other treatments, presented amplitude of the CIs that covered the DM of the feed provided, different of the result obtained for the floor system. All other variables evaluated in the production phase did not differ in the beak trimming methods and the amplitudes of the CI did not contemplate the means of the feed provided.

The higher mineral matter and the smaller MGD of orts in the cage system clearly indicates the selection of the ingredients with higher grain size, including maize, and exclusion of minerals, including calcitic limestone. These results are associated with the factors previously discussed in the growing phase in terms of exposure time and type of feeder systems.

The results reported in the production phase partially disagree with PRESCOTT & BONSER (2004), who reported that the trimming was well done, there were several benefits to production, including less feed selection, reduction of waste and consequently improved feed conversion. However, the other possible benefits of trimming should be taken into account, including reduction of the occurrence of cannibalism and pecking-related egg breaking/loss.

Our results provided complementary information regarding the management of beak trimming, especially when they are related to animal welfare standards. According to BROOM & MOLENTO (2004), beak trimming is critical to laying hens welfare, since it is a mutilation and causes pain. However, these same authors point out that in some situations and depending on the method used, trimming is necessary to combat other hazards well-being, including cannibalism and feathering, which are cited as indicators of low animal well-being.

It is important to highlight that we showed the effect of a rearing system on the birds' selection capacity for specific fractions of the feed. This effect may have been influenced by the type of feeder, density of the system, presence or not of litter and nest, and greater environmental enrichment in the floor system, among other influences.

In order to minimize feed selectivity, our data suggested that beak trimming was not adequate to completely minimize feed selection. In addition, differences in orts in relation to feed provided suggested that there was a difference in feeding behavior, possibly compromising performance and benefit regardless of the treatment. Other alternatives including pelleting could be used as a methodology to minimize feed selection.

However, further studies should be carried out in which other variables such as feed wastage and excreta composition are evaluated, to provide a better understanding of the bird behavior regarding ingredient selection according to different trimming methods.

CONCLUSION

Beak trimming was insufficient to prevent the selection of feed components. The floor-rearing system resulted in a greater selectivity in the growing phase and less selectivity in the production phase.

ACKNOWLEDGEMENTS

To the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) by the research grant, under edict 05/2015.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

The experiment was approved by the animal ethics committee of the State University of Santa Catarina (protocol number 1961120216).

DECLARATION OF CONFLICTING INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHOR'S CONTRIBUITIONS

The authors contributed equally to the manuscript.

REFERENCES

BAGGIO, R. A. et al. Desempenho de galinhas poedeiras nas fases de cria e recria submetidas a diferentes métodos de debicagem In: XXVII CONGRESSO BRASILEIRO DO ZOOTECNIA, 2017, Santos, SP. **Anais...** XXVII Zootec, 2017.

BROOM, D.M.; MOLENTO, C.F.M. Animal welfare: concept and related issues. Review. **Archives of Veterinary Science**, v.9, n.2, p.1-11, 2004. Available from: <http://revistas.ufpr.br/veterinary/article/view/4057>. Accessed: Feb. 20, 2017. doi: 10.5380/avs.v9i2.4057.

CARVALHO, L.C. Welfare of Laying Hens Production – Literature Review. **Revista Científica de Medicina Veterinária**, v. 28, n.0, 2017. Available from: <http://faef.revista.inf.br/imagens_arquivos/arquivos_destaque/w9h0rwyRxbJgkyH_2017-3-2-21-47-54.pdf>. Accessed: May 27, 2017.

DENNIS, R. L.; CHENG, H. W. A comparison of infrared and hot blade beak trimming in laying hens. **Journal of Poultry Science**, v. 9, n. 8, p. 716-719, 2010. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/19096054>. Accessed: Oct. 8, 2015. doi: 10.3382/ps.2008-00227.

HANDERSON, S. M.; PERRY, R. L. **Agricultural process engineering**. New York: John Wiley and Sons, 1955, p. 402.

HY-LINE. Management Guide of Laying Hens. 2014. Available from: <http://hyline.tempsite.ws/hyline/download/guia_brown_2014.pdf>. Accessed: Jun. 08, 2017.

JENDRAL, M. J.; ROBINSON, F. E. Beak trimming in chickens: historical, economical, physiological and welfare implications, and alternatives for preventing feather pecking and cannibalistic activity. **Avian and Poultry Biology Reviews**, v. 15, n. 1, p. 9-23, 2004. Available from: <https://academic.oup.com/ps/article/86/9/1831/1581961/The-Effects-of-Different-Bill-Trimming-Methods-on>. Accessed: Sept. 25, 2015. doi: 10.1093/ps/86.9.1831.

KUENZEL, W. J. Neurobiological basis of sensory perception: welfare implications of beak trimming. **Journal of Poultry Science**, v. 86, n. 6, p. 1273–1282, 2007. Available from: <https://academic.oup.com/ps/article/86/6/1273/1579952>. Accessed: Nov. 15, 2015. doi: 10.1093/ps/86.6.1273.

MARCHANT-FORDE, R. M.; FAHEY, A. G.; CHENG, H. W. Comparative effects of infrared and One-Third Hot-Blade Trimming on Beak Topography, Behavior, and Growth. **Journal of Poultry Science**, v.87, p.1474-1483, 2008. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/18648038>. Accessed: Feb. 25, 2016. doi: 10.3382/ps.2006-00360.

PETROLLI, T. G. Effects of laser beak Trimming on the Development of Brown Layer Pullets. **Brazilian Journal of Poultry Science**, v. 19, n. 1, p. 123-128, 2017. Available from: <http://www.scielo.br/pdf/rbca/v19n1/1516-635X-rbca-19-01-00123.pdf>. Accessed: Mar. 12, 2018. doi: 10.1590/1806-9061-2016-0307.

PRESCOTT, N. B.; BONSER, R. H. C. Beak trimming Reduces Feeding Efficiency of Hens. **Journal of Applied Poultry Research**, v.13, p.468–471, 2004. Available from: <https://academic.oup.com/japr/article/13/3/468/768015/Beak-Trimming-Reduces-Feeding-Efficiency-of-Hens>. Accessed: Aug. 15, 2017. doi: 10.1093/japr/13.3.468.

ROSTAGNO, H. L. et al. 2011. Exigências nutricionais de Aves de Reposição e de Galinhas Poedeiras. Pages 125-141. In: ROSTAGNO, H. L. (ed). **Tabelas brasileiras para aves e suínos**: composição de alimentos e exigências nutricionais. 3. ed. – Viçosa, MG: UFV, DZO, 2011.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos**: Métodos químicos e biológicos. 3d. - Viçosa, MG: UFV, 2002.

VIEIRA FILHO, J. A. et al. Índice produtivo e qualidade de ovos de galinhas poedeiras submetidas a diferentes métodos de debicagem. **Pesquisa agropecuária brasileira**, Brasília, v.51, n.6, p.759-765, jun. 2016. Available from: <http://www.scielo.br/pdf/pab/v51n6/1678-3921-pab-51-06-00759.pdf>. Accessed: Mar. 15, 2017. doi: 10.1590/S0100-204X2016000600008.