Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

The effect of feed transportation and an automatic feeding system on the physical and chemical quality of pelleted feed for broiler chickens

Lorenzetti, W.R.[1]; Lorenzetti, R.G.[2]; Sachet, J.P.[1]; Migliorini, M.J.[1]; Barreta, M.[1]; Paiano, D.[1]; Zampar, A.[1]; Da Silva, A.S.[1]; Boiago, M.M.[1@]

[1]Department of Animal Science - Universidade do Estado de Santa Catarina, Chapecó, SC, Brazil.
[2]Veterinarian, Santa Catarina, Brazil.

ADDITIONAL KEYWORDS
Helicoid.
Mineral matter.
Pellet.
Segregation.

SUMMARY

The effects of feed transportation and the use of an automatic feeding system on chemical-physical characteristics of pelleted feed for broiler chickens at the final stage of production were evaluated. Samples were collected in two consecutive days and in two different poultry houses, both equipped with the same type of automatic pan feeding system. The samples were collected at the exit of the pelletizer dryer (PEL), at the exit of the bulk truck (CAM) and at 0 (LIN0), 50 (LIN50) and 100 (LIN100) meters of the feed line, for analysis of water activity, dry matter, mineral matter, crude protein, Embrapa Pelletizing Evaluation Method, Pellet Durability Index, as well as coarse and fine percentages. It was used a complete randomized block design (DBC) with five treatments (collection points) and five replicates each. The results indicate that the physical feed quality was negatively affected by transportation, with increased ($P<0.05$) water activity, fine particles ($P<0.001$) and mineral matter at the beginning of the feed line. There was no change in crude protein levels in the dry and natural matter of the diet ($P>0.05$). Feed truck unloading at the silo is the main factor affecting its physical quality causing greater pellet breakdown and de-mixing.

Efecto del transporte y de un sistema automático de alimentación sobre la calidad física y química de los piensos granulados para pollos de engorde

PALABRAS CLAVE ADICIONALES
Materia mineral.
Helicoide.
Bolita.
Segregación.

RESUMEN

Evaluamos los efectos del transporte y del sistema de alimentación automática sobre las características químicas y físicas de los alimentos peletizados para pollos de engorde en la etapa final de producción. Las muestras se recogieron en dos días y en dos gallineros diferentes, ambos equipados con el mismo tipo de sistema automático de alimentación de placas. Las muestras se recolectaron a la salida del secador de peletización (PEL), a la salida del camión a granel (CAM) y a los 0 (LIN0), 50 (LIN50) y 100 (LIN100) metros de la línea de alimentación, para el análisis de actividad del agua, materia seca, materia mineral, proteína bruta, MEP (Método de Evaluación de Pelletización, Embrapa), IDB (Índice de Durabilidad del Bolita) y porcentajes gruesos y finos. Empleamos un diseño de bloques completos al azar con cinco tratamientos (puntos de recolección) y cinco repeticiones. Los resultados indican que la calidad física de la alimentación se vio afectada negativamente por los factores involucrados en el proceso de transporte, con mayor actividad de agua ($P<0.05$), aumento de partículas finas ($P<0.001$) y mayor porcentaje de materia mineral ($P<0.05$) al comienzo de la línea de alimentación. No hubo cambios en los niveles de proteína cruda en la ración seca y natural de la dieta ($P>0.05$). La descarga de la ración en el silo de la granja por el camión de grano es el factor de mayor descomposición de los pellets y la mezcla de la ración.

INFORMATION
Cronología del artículo.
Recibido/Received: 18.05.2018
Aceptado/Accepted: 13.08.2018
On-line: 15.07.2019
Correspondencia a los autores/Contact e-mail:
mmboiago@gmail.com

INTRODUCTION

Constant advances in many aspects of animal production provided better results in poultry farming. Despite them, most of the productive expenses of the activity have been related to animal feeding, representing more than 60-70 % of its total cost. According to Paiano *et al.* (2014), the maximum nutritional utilization of food depends on numerous factors involved on feed production, especially the mixture.

Pelletization is a mechanical process that combines food particles using high temperature (80 - 90 °C) and steam, with the objective to form pellets resilient to transportation and handling (Cardeal *et al.*, 2014), leading to low amounts of fine particles (Amerah *et al.*, 2007), related to feed fragmentation and abrasion resistance (Abdollahi *et al*., 2013). The supply of pelleted or mash feed for broiler chicks in the initial phase allows greater consumption, metabolization and retention of energy intake (Freitas *et al*., 2008), as well as improves nutrient digestibility and reduces feeding time, which favors weight gain (Engberg *et al*., 2002). Pellet integrity indexes of 60-64 % may result higher feed conversion, greater weight gain and better feed efficiency of broiler chickens (Mckinney & Teeter, 2004; Corzo *et al*., 2011).

To determine the pellet's quality, through its durability, the method known as PDI (Pellet Durability Index) determines the percentage of material retained in the sieve after challenge. Schmidt *et al*. (2004) developed a practical method for determining % PDI, known as Embrapa Pelletizing Evaluation Method (MEP), which by means of a mathematical equation, indicates the % PDI. Cardinal *et al.* (2014) evaluated the quality of the pellet from the pelletizer up to the end of the line of feeding used to broiler chickens, conclusion being that the MEP method was more suitable to assess pellet than the PDI. However, these authors did not evaluated the effect of the factors on the chemical composition of the feed, which is a relevant parameter for good animal performance.

Thus, the aim of this study was to evaluate the effects of feed transportation and an automatic feeding system on chemical and physical characteristics of broiler chicken pelleted feed.

MATERIAL AND METHODS

Sampling

Samples of pelleted feed were collected at different points, from the pelletizer dryer up to the end of the feeding line (100 m) and made of corn, soybean meal, degummed soybean oil, dicalcium phosphate, calcitic limestone in addition to vitamin and mineral premixes. The samples were collected on two different days and at two different farms of 100 x 12 m poultry houses equipped with automatic pan type feeders of the same brand, with the feed being distributed by a helical system coupled to a metal tube of 7.5 cm in diameter. Distance between the feed mill and the farm in average was 30 km and 60 % of this journey was made trough tarmacked road while the remaining 40 % was made of dirt. Chemical and physical analyses involved the samples being collected at five points: pelletizer dryer exit (PEL), point from the feed truck exit in the farm's feed bin (CAM), in the first feeder (LIN0), 50 meters (LIN50) and 100 meters up (LIN100) the feeding trough line. Procedure used was random block design (RBD) with five treatments (collection points) and five repetitions with approximately 1000 g of feed each.

Sample preparation and laboratory analyses

Samples (1000 g) were placed in plastic bags and transported to the Laboratory of Animal Nutrition (LANA), at the Animal Science Department of University of Santa Catarina State - UDESC/CEO, where it was riffled in a Jones splitter. Aliquots obtained were separated for bromatological and physical analyses. Water activity (WA) analysis was performed using AQUALAB LITE equipment (DECAGON Devices Inc., USA). Dry matter (DM), crude protein (CP) and mineral matters (MM) were also evaluated according to Silva & Queiroz (2002). Physical analyses involved weighing 300 g (± 20 g) of the sample for further cascade screen-

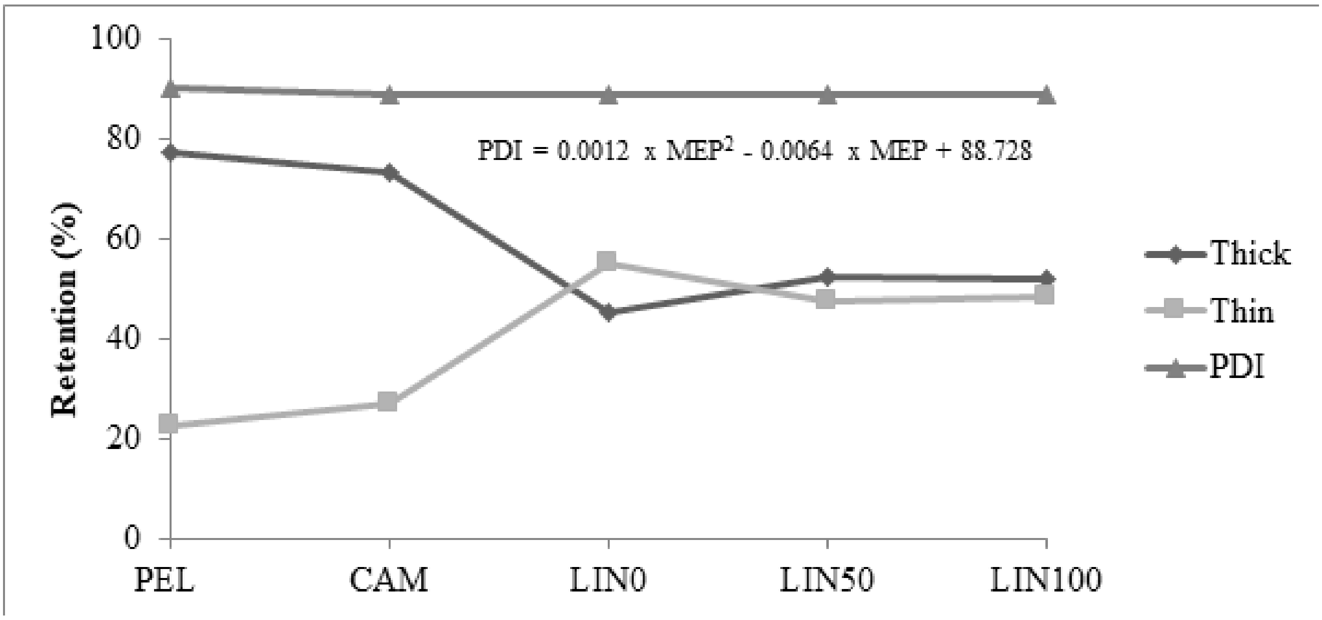

Figure 1. Average values for PDI and total thick and thin. The transport and unloading activity by truck is the factor of greater breakdown of pellets, demonstrated by the inversion of the lines in the point LIN0; PEL – exit of the pelletizer dryer; CAM – Truck exit; LIN0 – Beginning of the feeding trough line; LIN50 – 50 m; LIN100 – 100 m along the feeding trough line (Valores medios para PDI, grosor y delgadez total. La actividad de transporte y descarga por camión es el factor de mayor descomposición de los pellets, demostrado por la inversión de las líneas en el punto LIN0; PEL – salida del secador de pelletizadores; CAM – Salida del camión; LIN0 – Inicio de la línea del canal de alimentación; LIN50 – 50 m; LIN100 – 100 m a lo largo de la línea de la vaguada de alimentación).

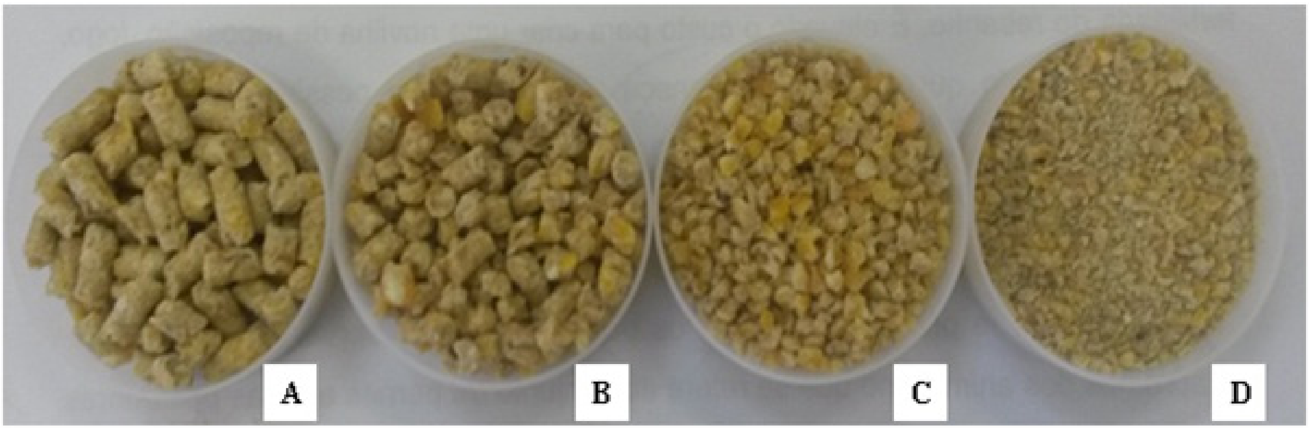

Figure 2. Characterization of the fractions retained in the sieves 4.00 (A), 2.36 (B), 2.00 mm (C) and Tray (D) (Caracterización de las fracciones retenidas en los tamices 4.00 (A), 2.36 (B), 2.00 mm (C) y Bandeja (D).

ing in an electromagnetic agitator (Tamis® - Bertel) device for 30 seconds, with 60 vibrations per cycle. Sieves at size Tyler 5 (4.00 mm), Tyler 8 (2.36 mm), Tyler 10 (2.00 mm) and a bottom tray (0 mm), were used to quantify the percent of thin (**Figures 1 and 2**).

Evaluation of the pellet quality

Following the screening, the percentages of feed retained in each sieve were calculated. MEP (Embrapa Pelletizing Evaluation Method - %) was obtained using the percentage retained in the 4 mm sieve, in accordance to Schmidt *et al.* (2004). The PDI – Pellet Durability Index value (%) was also calculated according to the equation PDI = 0.0012 x MEP^2 – 0.0064 x MEP + 88.728 (R^2 = 0.958), as described by Schmidt *et al.* (2004).

RESULTS

The water activity was significatively higher (**Table I**) in samples collected at 50 and 100 meters from the feeder line (LIN50 and LIN100), when compared to those collected at the exit of the dryer (PEL). The dry matter was lower in LIN50 compared to PEL and the CAM. There was an increase ($P<0.05$) in the average values of mineral matter of the samples collected at the beginning of the feed line (LIN0) when compared to those collected of the truck output (CAM), with subsequent reduction, evidenced by the difference between LIN0 and LIN100 points (beginningt and end of the line). There were no significant differences for crude protein on dry and natural matter ($P>0.05$).

Physical changes were observed in all treatments (**Table II**). The retention in the sieve 4.00 mm (MEP) reduced ($P<0.001$) between the samples collected at the pelletizer dryer exit (PEL) and unloading of the feed by the truck to the farm's feed bin (CAM), while along the feed line no changes were observed.

Percentage of feed retained in the 2.00 mm sieve was higher ($P<0.001$) at the points along the feed line compared to the two initial points (**Table II**). In addition, the percentage of feed retained at the beginning of the line (LIN0) was lower than the retention of samples collected at 100 meters from the feed line (LIN100). Percentage of thick and thin particles had an inverse behavior before and after the beginning of the feed line (**Figure 1**), represented by difference ($P<0.001$) between the proportion of the particles thick and thin.

DISCUSSION

Table I. Average values for water activity (WA), percent (%) of dry matter (DM), mineral matter (MM), crude protein in the dry matter (CPDM) and crude protein in natural matter (CPNM) from the feed samples collected at the different points (Valores medios para la actividad hídrica (WA), porcentaje (%) materia seca (DM), materia mineral (MM), proteína bruta en la materia seca (CPDM) y proteína bruta en materia natural (CPNM) de las muestras de pienso recogidas en los diferentes puntos).

Collection points	WA	DM	MM	CPDM	CPNM
PEL	0.598 ^{b}	89.07 ^{a}	4.55 ^{b}	19.17	17.11
CAM	0.605 ^{ab}	89.11 ^{a}	4.50 ^{b}	19.34	17.23
LIN0	0.603 ^{ab}	88.82 ^{ab}	5.26 ^{a}	19.61	17.37
LIN50	0.609 ^{a}	88.64 ^{b}	4.89 ^{ab}	19.17	16.99
LIN100	0.610 ^{a}	88.95 ^{ab}	4.69 ^{b}	19.11	17.00
p Value	<0.05	<0.01	<0.05	0.056	0.072
CV (%)	0.99	0.29	8.95	2.86	2.90

$^{a, b, c}$ Different letters in the same column differ statistically between themselves by Tukey test (5%); Coefficient of variation (CV); PEL – exit of the pelletizer dryer; CAM – Truck exit; LIN0 – Beginning of the feeding trough line; LIN50 – 50m; LIN100 – 100m along the feeding trough line.

Table II. Mean values obtained for the feed retention percentage in the 4.00 mm sieves (MEP); 2.36; 2.00 mm; total thick, totals thin (<2.00 mm) and PDI at the different collection points (Valores medios obtenidos para el porcentaje de retención de piensos en los tamices de 4,00 mm (MEP); 2.36; 2,00 mm; total grueso, totales delgados (<2,00 mm) y PDI en los diferentes puntos de recogida).

Collection points	Sieves (mm)			Total thick	Total thin	PDI***
	4.00	2.36	2.00			
PEL	37.45 [a]	37.21 [b]	2.82 [c]	77.49 [a]	22.51 [b]	90.09 [a]
CAM	20.09 [b]	50.06 [a]	2.97 [c]	73.12 [a]	26.88 [b]	89.04 [b]
LIN0	6.63 [c]	34.19 [b]	4.22 [b]	45.05 [b]	54.94 [a]	88.74 [c]
LIN50	4.79 [c]	42.83 [ab]	4.72 [ab]	52.35 [b]	47.65 [a]	88.73 [c]
LIN100	4.65 [c]	42.11 [ab]	4.94 [a]	51.71 [b]	48.28 [a]	88.73 [c]
P Value	<0.001	0.0041	<0.001	<0.001	<0.001	<0.001
CV (%)	33.33	21.96	14.05	16.91	25.31	0.22

[a, b, c] Different letters in the same column differ statistically between themselves by Tukey test (5%); Coefficient of variation (CV); PEL – exit of the pelletizer dryer; CAM – Truck exit; LIN0 – Beginning of the feeding trough line; LIN50 – 50 m; LIN100 – 100 m along the feeding trough line. ***According to Schmidt *et al.* (2004).

Changes in the mineral content demonstrate a detrimental effect that feed transportation may exert on pellet integrity and feed quality. Our results indicate a significant increase of minerals at the beginning of the feeding line, corroborating with Cardinal *et al.* (2014), who reported the same effect on the first feeder. This increase in the mineral matter percentage can be related to a decrease in the percentage of healthy material (thick) from the first feeder (LIN0) and a consequent accumulation of thin, consisting of higher-density particles that comprise the minerals in the feed, sourced from minerals such as calcitic limestone and dicalcium phosphate. Klein (1999) considered the desmixing points within the actions of the screw threads, screens, lifts and feed bins (free fall) as critical. This fall can result in particles being separated, which is a process influenced by difference in the specific weight that is due to the characteristics of the rWA material. Paiano *et al.* (2014) reported that ingredients with excessively different physical characteristics can segregate and promote desmixing of the feed, which may explain the results obtained during this study. In a study performed by Scheideler (1995) for evaluate pellets quality, the percentages of thick in the feed mill pellet cooler, transportation through feed truck and feeding troughs, can deteriorate and induce the end of process, reach 66.6, 48 and 41.5 %, low values than those found in our study (77.49, 73.12 and 45.05 %) at the same collection stages, respectively.

Although few used, water activity (WA) proved to be an important tool in the quality control of feed. No information has been found in the literature on the routine use of this parameter and, possibly, our study provide the first investigation with pelleted feed. According to Reid & Fenema (2010), feeds with the same water content differ significantly in terms of perishability due the intensity differences with which water is associated the non-aqueous components, lower WA decrease of microorganisms and hydrolytic reactions developing. Even at the end of the feeding trough line the WA value found (0.61) was not conducive to microorganism development. According to Aqualab (2016), substrates containing levels of WA lower than 0.6 preclude the growth of any microorganism, while levels above 0.61 to 0.87 WA allow the deterioration of food by the action of some xerophilic fungi and, from 0.88 to 0.97 WA is advantageous to most pathogenic bacteria. Our study revealed levels close to 0.6 WA remaining below the critical range.

Despite changes in pellet integrity, there were no significant changes in crude protein levels (Table 1). A plausible explanation for this could be that corn and soybean meal, which are the main contributors for providing crude protein in the feed have lower densities of the calcitic limestone and dicalcium phosphate, responsible for the bulk of the mineral matter in the feed used in this study. According to Lima & Nones (1997), ingredients such as corn and soybean meal have average densities of 0.75 and 0.68 g/cm^3, respectively, which are lower values than those found in vitamin and mineral premixes (1.18 g/cm^3). However, Clark *et al.* (2007) indicate that because it comes from different sources, the crude protein is not considered a great indicator of quality misture.

The metodology criated by Schmidt *et al.* (2004) for evaluate pellets quality by of MEP showed an aplication different in compared official method (PDI). According to Cardeal *et al.* (2014) the PDI value does not show the real situation regarding the relationship between whole pellets and thin offered to animals as feed on the farm, which is demonstrated by MEP. Therefore, the PDI is a good method to evaluate pellet resistance in the feed mill, because there is high correlation with the MEP, which proved to be best method to evaluate the condition of the pellet in the field.

Feed composition was negatively affected by the transportation process, with a variation in water activity, mineral and dry matter trough the feeding line. Pellet quality was also negatively affected, with higher impact at the interval between truck exit and the beginning of the feeding line. In addition, there was no variation on crude protein levels in the dry and natural matter from the feed.

BIBLIOGRAPHY

Abdollahi, MR, Ravindran, V & Svihus B 2013, 'Pelleting of broiler diets: An overview with emphasis on pellet quality and nutritional value', *Animal Feed Science and Technology*, vol. 179, no. 4, pp.1–23.

Amerah, AM, Ravindran, V, Lentle, RG & Thomas DG 2007, 'Feed particle size: Implications on the digestion and performance of poultry', *World's Poultry Science Journal*, vol. 63, no.3, pp.439-455.

Aqualab. Water activity for product safety and quality. Disponível em: <http://www.aqualab.com/education/water-activity-for-product-safety-and-quality/>. Acesso em: 22 out. 2016.

Cardeal, PC, Rocha JSR, Ferreira HC, Santos CH, Pompeu MA, Cunha CE, Baião NC & Lara, LJC 2014, 'Efeito do transporte de pellets sobre sua qualidade', *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, vol. 66, no.5, pp.1618-1622.

Cardinal, KM, Vale, MM, Alonço, AS, Borille, R, Klein, DR & Naas, IA 2014, 'Feed ration homogeneity during distribution of broilers automatic feeders', *Brazilian Journal of Biosystems Engineering*, vol. 8, no. 4, pp.280-288.

Corzo, A, Mejia, L & Loar, RE II 2011, 'Effect of pellet quality on various broiler production parameters', *The Journal Applied Poultry Research*, vol. 20, no.1, pp.68-74.

Clark, PM, Behnke, KC & Poole, DR 2007, 'Effects of marker selection and mix time on the coefficient of variation (mix uniformity) of broiler feed', *Journal of Applied Poultry Research*, vol.16, no.3, pp.464-470.

Engberg, RM, Hedemann, MS & Jensen, BB 2002, 'The influence of grinding and pelleting of feed on the microbial composition and activity in the digestive tract of broiler chickens', *British Poultry Science*, vol.43, no.4, pp.569-579.

Freitas, ER, Sakomura, NK, Dahlke, F, Santos, FR & Barbosa, NAA 2008, 'Desempenho, eficiência de utilização dos nutrientes e estrutura do trato digestório de pintos de corte alimentados na fase pré-inicial com rações de diferentes formas físicas', *Revista Brasileira de Zootecnia*, vol.37, no.1, pp.73–78.

Klein, AA 1999, 'Pontos críticos do controle de qualidade em fábricas de ração - Uma abordagem prática', *I Simpósio Internacional ACAV - Embrapa sobre nutrição de aves*. Disponível em: <https://docsagencia.cnptia.embrapa.br/suino/anais/anais56_klein.pdf>. Acesso em 21 out.2016.

Lima, GJMM & Nones, K 1997, 'Os cuidados com a mistura de rações na propriedade.' Embrapa Suínos e Aves. *Circular Técnica 19*. Disponível em: <https://www.infoteca.cnptia.embrapa.br/bitstream/doc/433733/4/CUsersPiazzonDocumentsCIT19.pdf. Acesso em 07 nov. 2016.

Mckinney, LJ & Teeter, RG 2004, 'Predicting effective caloric value of nonnutritive factors: I. Pellet quality and II. Prediction of consequential formulation dead zones', *Poultry Science*, vol. 83, no.7, pp.1165-1174.

Paiano, D, Biazzi, HM, Trevisan, C, Casarotto, S, Zimmer, F, Krahl, G & Lopes, LS 2014, 'Macro ingredientes como indicadores da qualidade de mistura de rações', *Semina: Ciências Agrárias*, vol.35, no.3, pp.1463-1474.

Reid, DS, & Fennema, OR 2010. Água e gelo. Química de alimentos de Fennema. 4. Ed. Porto Alegre: Artmed, p.26 – 74, 2010.

Scheideler, SE 1995. 'Poultry feeds: Is pelleting cost effective?' *Feed Management*, vol.46, no.3, pp. 21-26.

Schimidt, A, Coldebella, A & Lima, GJMM 2004, 'Método Embrapa de avaliação de peletização'. *Comunicado Técnico*. Disponível em:http://ainfo.cnptia.embrapa.br/digital/bistream/item/85845/1/DCOT-369.pdf. Acesso em: 19 mar.2015.

Silva, DJ & Queiroz, AC. Análise de alimentos: Métodos químicos e biológicos. 3d.Viçosa, MG: UFV, 2002.