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NONRUMINANT NUTRITION

Performance and carcass yield of female broilers fed with diets containing probiotics and symbiotics as an alternative to growth enhancers

Gabriela Viana da Silva[1*], Noédson de Jesus Beltrão Machado[2], Leonardo Willian de Freitas[2], Marcos Fábio de Lima[3] and Rosa Helena Luchese[1]

*[1]Departamento de Tecnologia de Alimentos, Universidade Federal Rural do Rio de Janeiro, Rodovia BR-465, Km 07, Seropédica, Rio de Janeiro, Brasil. [2]Departamento de Nutrição Animal e Pastagens, Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro, Brasil. [3]Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro, Pinheiral, Rio de Janeiro, Brasil. *Autor para correspondência. E-mail: gabrielaufrrj@ig.com.br*

ABSTRACT. An experiment was carried out with female broilers, aiming to evaluate the effect of using probiotics and symbiotics on growth performance and yield of carcasses and of the main commercial cuts and edible viscera. A total of 720 one-day-old Cobb chicks, distributed in a completely randomized experimental design with four treatments and six replicates of 30 birds each at a stocking density of 10 birds per square meter (m^2). At 42 days old two broilers of each experimental unit were sacrificed to evaluate the carcass yield and its parts. The carcass yield was not affected by the inclusion of probiotics and symbiotics in the diet being equivalent to the antibiotic group. No significant difference was observed among the treatments, even in the controls that did not receive any additive factor. All the performance parameters were similar for the four treatments, with the exception of weight gain, that was significantly lower in probiotic treatment. It was concluded that these additives are important alternative to replace antibiotics as growth enhancers, which have already been banned in many countries.

Keywords: poultry farming; additions; performance.

Desempenho e rendimento de carcaças de frangos de corte fêmeas alimentados com dietas contendo probióticos e simbióticos como alternativa aos melhoradores de crescimento

RESUMO. Foi realizado um experimento com frangos de corte fêmeas, objetivando-se avaliar o efeito da utilização de probióticos e simbióticos sobre o desempenho e rendimento de carcaça e dos principais cortes comerciais e vísceras comestíveis destes animais. Foram utilizados 720 pintos de um dia de idade da linhagem Cobb, distribuídos em um delineamento experimental inteiramente casualizado, com quatro tratamentos e seis repetições de 30 aves cada em uma densidade de 10 aves/metro quadrado (m^2). Aos 42 dias de idade foram abatidos dois frangos por repetição, para a avaliação do rendimento de carcaça e suas partes. A inclusão de probióticos e simbióticos na ração não proporcionou diferença significativa no rendimento de carcaça e suas partes sendo equivalente ao tratamento com antibióticos. Não foi observada diferença significativa entre os tratamentos, inclusive nos controles que não receberam qualquer fator aditivo. Da mesma forma os demais parâmetros de desempenho foram equivalentes para os quatro tratamentos, com exceção do ganho de peso, que foi significativamente menor no tratamento probiótico. Conclui-se que esses aditivos são uma alternativa importante na substituição dos antibióticos como melhoradores de crescimento, os quais já foram banidos em muitos países.

Palavras-chave: avicultura; aditivos; desempenho.

Introduction

The first scientific work related to the use of antimicrobials in animals was published in 1949, which demonstrated the beneficial effect of the use of chlortetracycline at sub therapeutic levels for birds. Excess residues from the fermentation of this tetracycline proved to improve the growth and health of the animals (Guardabassi, Jasen, & Kruse, 2009).

However, the excessive use of antibiotics in food production of animal origin has contributed to the appearance of bacterial resistance in these animals, which is a cause of worldwide concern (Garcia-Migura, Hendriksen, Fraile, & Aarestrup, 2014). Considering that these animals are intended for human consumption, it is possible for these bacteria and their resistance genes to be transmitted and incorporated into the human microbiota, thus reducing the effectiveness of antimicrobials (Chantziaras, Boyen, Callens, & Dewulf, 2013; Stanton, 2013). With the banning of these drugs in European Union countries, poultry meat producer companies had to adapt, improving management practices and biosafety, genetic selection, environmental control of facilities and changes in diet composition and in the poultry feed program (Costa, Oliveira, Ramos, & Bernardo, 2011) and it has caused the need for researching new products and promising results that can replace antibiotics. Enzymes, acids, prebiotics and probiotics, herbs or etheric oils are some examples of classes of products that are used as growth enhancers alternatives to antibiotics (Huyghebaert, Ducatelle, & Van Immerseel, 2011). Probiotics are products composed of live microorganisms used to beneficially affect the host animal, promoting intestinal microbiota balance (Fuller, 1989). They act by maintaining normal intestinal microbiota by competitive exclusion and antagonism; they alter metabolism by increasing digestive enzymatic activity and decrease bacterial enzymatic activity and ammonia production; they improve food intake and digestion, and stimulate the immune system (Kabir, 2009; Perumalla, Hettiarachchy, & Ricke, 2011). Prebiotics were defined by Gibson and Roberfroid (1995) as non-digestible ingredients that stimulate the growth and/or activity of a selected number of bacteria in the gastro-intestinal tract and improve host health. Symbiotics, are products in which the combination of prebiotic and probiotic occurs. The objective of this study was to evaluate growth performance and carcass yield, as well as commercial cuts and edible viscera yields of female broilers fed diets containing antibiotic, probiotic and symbiotic, at the 42th day of life.

Material and methods

All the procedures performed in this research were approved by the Animal Ethic Committee of the Federal Rural University of Rio de Janeiro under number 450/2014.

The experiment was carried out at the Poultry Research Center of the Federal Institute of Rio de Janeiro – in Pinheiral, Rio de Janeiro. A total of 720 one-day-old female broilers of the Cobb lineage vaccinated against Marek’s disease, Avian Bouba, Infectious Bronchitis and Gumboro. One-day-old chicks were weighed and housed, according to mean weight, in experimental boxes, with a bed of wood previously used by a lot of chickens, in order to increase the sanitary challenge. Heating program, with 24h of brightness (natural and artificial light) was applied during the first ten days of birds life when they received, artificial light continuously. The experimental design was completely randomized, with four treatments, six replicates and 30 birds per experimental unit at a density of 10 birds/square meter (m^2). The experimental treatments were: control (reference ration); probiotic (Novartis); symbiotic (probiotic and prebiotic) and antibiotic (avilamycin 12%).

Novartis's probiotic Protexin Concentrate® is composed of *Lactobacillus plantarum* strains 1.26 x 10^8 CFU g^{-1}, *Lactobacillus bulgaricus* 2.06 x 10^8 CFU g^{-1}, *Lactobacillus acidophilus* 2.06 x 10^8 CFU g^{-1}, *Lactobacillus rhamnosus* 2.06 x 108 CFU g^{-1}, *Bifidobacterium bifidum* 2.00 x 10^8 CFU g^{-1}, *Streptococcus thermophilus* 4.10 x 10^8 CFU g^{-1} and *Enterococcus faecium* 6.46 x 10^8 CFU g^{-1}. The symbiotic used was composed of the mixture of probiotic Protexin Concentrate® plus the prebiotic BioMos of NutriCamp that has as active principle a mananoligosaccharide derived from the cell wall of the yeast *Saccharomyces cerevisae*. The inclusion of each test additive in the experimental diets was performed according to the manufacturer’s recommendations.

The experimental rations were formulated based on corn, soybean meal, vitamin and mineral supplementation, to meet the nutritional requirements of the lineage recommended by Rostagno et al. (2011), with water and feed provided *ad libitum* throughout the experiment.

For growth performance evaluation, final weight, weight gain, feed intake, feed conversion and viability were calculated by the formula (feed intake/final weight of birds + weight of dead birds). All these results were corrected in relation to mortality.

To evaluate the carcass yield and commercial cuts (chest, back, thigh and wing) at 42 days old (end of the experiment) after a fasting period of 8 hours, two birds from each box were selected, weighed and identified by plastic numbered labels and slaughtered, by cervical rupture. After slaughter, bleeding, scalding and removing chicken feathers, the carcasses were eviscerated, heads and feet were separated and weighed. Then they were submitted to cuts (chest, back, thighs, wings). The edible viscera (liver, heart and gizzard) were separated to weigh, the gizzard was weighed after opening and removal of feed residues. The percentage yield of cuts and visceras were calculated by the formula (carcass weight + edible viscera/pre-slaughter live weight x 100) as a function of the weight of the eviscerated carcass (without feet and head).

Data was submitted to analysis of variance using the linear model of the statistical analysis program SISVAR (Ferreira, 2011), developed by *Universidade Federal de Lavras – UFLA*. The Tukey average test at 5% probability was used to compare the significant differences among the treatments.

Results and discussion

Analyzing data for the performance characteristics (Table 1), in the breeding period of up to 42 days, it was observed that the treatments did not influence ($p > 0.05$) on the variables, feed intake, feed conversion and viability, but there were significant effects ($p < 0.05$) for body weight, weight gain. According to Edens (2003), the inclusion of desirable organisms (probiotics), in the diet, allows the fast development of beneficial bacteria in the digestive tract of the host, improving their performance. To be effective a probiotic a minimum number of 10^6 CFU g^{-1} of intestinal content is needed (Guillot, 2000). This number represents an estimate of the size of the bacterial population to be achieved to obtain a beneficial effect. In addition to the quantity used, another factor that interferes with the beneficial action is the species used.

Table 1. Mean of the variables at 42 days old of body weight, weight gain, feed conversion, feed intake and viability in Cobb lineage treated with avilamycin, probiotic, symbiotic and control.

Treataments	Average				
	Body weight, g	Weight Gain, g	Feed Intake, g	Feed Conversion, kg kg^{-1}	Viability (%)
Probiotic	2223.20 ^{ab}	2046.02 ^{a}	2945.78 ^{a}	1.52 ^{a}	98.33 ^{a}
Simbiotic	2207.57 ^{a}	2162.37 ^{b}	3156.76 ^{a}	1.43 ^{a}	97.50 ^{a}
Antibiotic	2295.67 ^{ab}	2248.68 ^{b}	3216.05 ^{a}	1.43 ^{a}	98.33^{a}
Control	2396.69 ^{b}	2322.40 ^{b}	2911.88 ^{a}	1.30 ^{a}	99.16 ^{a}
Coefficient of variation, %	3.84	4.13	8.48	7.27	1.83

*Average followed by the same letter in the column do not differ by Tukey test at a 5% probability level.

Weight gain was significantly lower ($p < 0.05$) in probiotic treated chicken when compared to treatments containing other growth factors and the control group. These results differ from those obtained by Schwarz, Kehrenberg and Walsh (2001) who found no statistical difference between antimicrobial and probiotic treatments in relation to bird weight gain. On the other hand, Yun, Lee, Choi, Kim and Cho (2017) observed a significant increase in weight gain when added to the broiler ration, a probiotic additive, consisting of *Bacillus, Lactobacillus and Aspergillus niger* species. Regarding the feed consumption, there was no statistical difference among the treatments. Rigobelo, Maluta and Ávila (2011) reported that in the period from 1 to 42 days, the lowest feed intake occurred with birds that received the probiotic comprised by *Lactobacillus acidophilus, Streptococcus faecium and Bifidobacterium bifidum* compared to the birds that received the antibiotic virginiamycin.

For feed conversion, the results found did not differ ($p > 0.05$) among the treatments. Similar results were found by Flemming and Freitas (2005) who did not observe difference in feed conversion among the additives, when testing an association of probiotics (*Bacillus subtilis* and *Bacillus licheniformis*) in comparison to the antibiotic avilamycin. However, when comparing them with the treatment without additive (control) there was a greater weight gain of those. According to Dibner and Richards (2005) the main objective of the use of antibiotics in feed is to improve feed conversion due to its effects on the intestinal microbiota and consequently in the efficiency of animal growth, and this effect was not observed in this experiment. This suggests that their use must not be compulsory in commercial farms that adopt good agricultural practices. The Brazilian Aviculture Union recommends that the maximum bird density per square meter should be 39 kg m^{-2}. This bird density is much higher than that practiced in the present research. Probably, if the conditions that are found on many commercial farms were reproduced, the results of the performances would be different.

Considering the breeding period, it was not detected any influence ($p > 0.05$) of the additives inclusion in mortality. This result differs from that found by Pelicano et al. (2003) who observed greater viability of broilers fed a combination of *Bacillus and Lactobacillus* probiotics and *Saccharomyces cerevisiae* as prebiotic For Lima, Pizauro Júnior, Macari and Malheiros (2003), probiotic action seems to be mainly related to two factors: the correct number and type of viable microorganisms present in the probiotic and the occurrence of stressing breeding conditions.

Inadequate environmental conditions reduce birds performance by directly affecting the immune response and consequently lowering live weight gain and food intake, so in that sense the inclusion of probiotics in the diet could induce changes through immunostimulation converting to improved performance (Takahashi, Akiba, and Matsuda, 1997).

No differences ($p > 0.05$) were observed between treatments for carcass yield and its parts (Table 2). To be considered an alternative to antibiotics, growth enhancers should improve animal performance at comparable levels (Huyghebaert et al., 2011). Under the conditions of the experiment, the use of probiotics and symbiotic as a growth factor showed the same efficiency of antibiotics in relation to cut and carcass yields. Similar results were reported by Mokhtari, Yazdani, Rezaei and Ghorbani (2010) who studied the effects of different growth factors including probiotic constituted of *Bacillus subtilis* and prebiotic β glucan and mannan on the performance and characteristics of broilers carcasses and verified that all growth promoters significantly increased carcass yield when compared to control.

Table 2. Average and coefficient of variation of the yield of commercial cuts of broiler chickens (chest, back, thighs, wings) and viscera (gizzard, heart and liver) evaluated at slaughter at 42 days old.

Treatament	Probiotic	Symbiotic	Antibiotic	Control	Coefficient of variation (%)
Carcass yield	72.909279 [a]	75.796548 [a]	71.917114 [a]	71.626563 [a]	7.85
Chest yield (%)	40.033620 [a]	38.385976 [a]	38.923622 [a]	38.366177 [a]	6.60
Thigh yield (%)	29.791137 [a]	30.355102 [a]	30.297502 [a]	30.133104 [a]	5.68
Wing yield (%)	11.244315 [a]	11.624767 [a]	11.344067 [a]	11.720168 [a]	11.25
Back yield (%)	18.622022 [a]	19.252548 [a]	19.480460 [a]	19.320527 [a]	8.17
Gizzard yield (%)	1.656133 [a]	1.711063 [a]	1.741357 [a]	1.692838 [a]	13.31
Liver yield (%)	2.850864 [a]	2.703781 [a]	2.557741 [a]	2.712758 [a]	19.88
Heart yield (%)	0.416283 [a]	0.447243 [a]	0.42879 [a]	0.410295 [a]	36.70

*Average followed by the same letter in the line do not differ by Tukey test at a 5% probability level.

Domingues et al. (2014) evaluated the effectiveness of using the *Bacillus subitilis* probiotic on the animal performance, carcass yield and parts of the carcass of broiler chickens at different stages of the breeding and also did not observe significant differences ($p > 0.05$) among treatments Santos Júnior, Ferket, Grimes and Edens (2004) verified that birds which were supplemented with symbiotic and antibiotic presented higher yield of thigh in comparison to the other treatments and suggested that the result was due to a greater deposition of nutrients in relation to the other treatments with consequences in the highest rate of growth and high rates of protein retention.

Albino et al. (2006) conducted a study using prebiotics (mananoligosaccharides) at different concentrations combined or not with the antibiotic avilamycin,and observed that the treatments improved the breast and breast fillet yields. On the contrary, in the present study significant differences for breast yield were not observed with the treatments used.

In the same way, there was no statistical difference ($p > 0.05$) among the treatments in relation of the edible yield viscera. Likewise, Paz et al. (2010) demonstrated that the use of antibiotics (avilamycin and colistin), prebiotics (mananoligosaccharides), probiotic (*Bacillus subtilis*) and organic acids (propionic acid and fumaric acid) did not affect ($p > 0.05$) liver, heart and intestine weight.

The results obtained corroborate with the observations of Caramori et al. (2008) and Bitterncourt et al. (2011). These authors suggested the possibility of using probiotics as a substitute for antibiotics, since the first is safe feed additive (*GRAS*) for the subsequent use of meat for human consumption. Luegas et al. (2015) point out that the sanitary and management conditions observed in commercial farms are not the same of those found in experimental breeding where birds are in conditions of minimum stress, making it difficult to verify any beneficial effect on the use of probiotics. There was no significant difference ($p < 0.05$) among the other treatments for the animal parameters such as performance in the period from 1 to 42 days old and the carcass yield and viscera. The importance of these conditions is also considered by Pedroso et al. (2006) who, besides the management and sanitary conditions, also state the influence of the type and concentration of probiotics used as well as the heterogeneity of broilers intestinal microbiota.

Although the results of research related to the use of performance balancers are conflicting, most of them show that their addition in the diet improve significantly or, at least, show broilers performance variables and in the carcass yield similar to antibiotics in the feed, at various stages of growth and there were no reasons for not using these additives in broilers breading.

Conclusion

According to the conditions of this study, the use of the probiotic Protexin Concentrate and the symbiotic (Protexin Concentrate + BioMos) was comparable to the antibiotic avilamycin in relation to the performance of 42 days old female broilers, at the time of slaughter, as well as in relation to the yield of cuts and viscera.

References

Albino, L. F. T., Feres, F. A., Dionizio, M. A., Rostagno, H. S., Vargas Júnior, J. G., Carvalho, D. C. O., ... Costa, C. H. (2006). Uso de prebióticos à base de mananoligossacarídeo em rações para frangos de corte. *Revista Brasileira de Zootecnia, 35*(3), 742-749.

Bitterncourt, L. C., Silva, C. C., Garcia, P. D. S. R., Donato, D. C. Z., Albuquerque, R., & Araújo, L. F. (2011). Influence of a probiotic on broiler performance. *Revista Brasileira de Zootecnia, 40*(12), 2739-2743.

Caramori Júnior, J. G., Rocha, R. L., Fraga, A. L., Vieites, F. M., Morcelli, L., & Gonçalves, M. A. (2008). Efeito de simbiótico na ração inicial de frangos de corte sobre o desempenho, qualidade de carcaça e carne. *Acta Scientiarum. Animal Sciences, 30*(1), 17-23.

Chantziaras, I., Boyen, F., Callens, B., & Dewulf, J. (2013). Correlation between veterinary antimicrobial use and antimicrobial resistance in food-producing animals: a report on seven countries. *Journal of Antimicrobial Chemotherapy, 69*(3), 827-834.

Costa, P. M., Oliveira, M., Ramos, B., & Bernardo, F. (2011). The impact of antimicrobial use in broiler chickens on growth performance and on the occurrence of antimicrobial-resistant *Escherichia coli*. *Livestock Science, 136*(2), 262-269.

Dibner, J. J., & Richards, J. D. (2005). Antibiotic growth promoters in agriculture: history and mode of action. *Poultry Science, 84*(4), 634-643.

Domingues, C. H., Santos, E. T., Castiblanco, D. C., Quadros, T. C. O., Petrolli, T. G., Duarte, K. F., & Junqueira, O. M. (2014). Avaliação do desempenho e rendimento de carcaça de frangos de corte alimentados com dietas contendo probiótico nas diferentes fases de criação. *Revista Agrocientífica, 1*(1), 7-16.

Edens, F. W. (2003). An alternative for antibiotic use in poultry: probiotics. *Revista Brasileira de Ciência Avícola, 5*(2), 75-97.

Ferreira, D. F. (2011). SISVAR: A Computer Statistical Analysis System. *Ciência e Agrotecnologia, 35*(6), 1039-1042.

Flemming, J. S., & Freitas, R. J. S. (2005). Avaliação do efeito de prebióticos (MOS), probióticos (*Bacillus licheniformis* e *Bacillus subtilis*) e promotor de crescimento na alimentação de frangos de corte. *Archives of Veterinary Science, 10*(2), 41-47.

Fuller, R. (1989). Probiotics in man and animals. *Journal of Applied Bacteriology, 66*(5), 365-378.

Garcia-Migura, L., Hendriksen, R. S., Fraile, L., & Aarestrup, F. M. (2014). Antimicrobial resistance of zoonotic and commensal bacteria in Europe: the missing link between consumption and resistance in veterinary medicine. *Veterinary Microbiology, 170*(1-2), 1-9.

Gibson, G. R., & Roberfroid, M. B. (1995). Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *Journal of Nutrition, 125*(6), 1401-1412.

Guillot, J. F. (2000). The pros and cons of probiotics-make probiotics work for poultry. *World Poultry, 16*(7), 18-21.

Huyghebaert, G., Ducatelle, R., & Van Immerseel, F. (2011). An update on alternatives to antimicrobial growth promoters for broilers. *The Veterinary Journal, 187*(2), 182-188.

Kabir, S. M. (2009). The role of probiotics in the poultry industry. *International Journal of Molecular Sciences, 10*(8), 3531-3546.

Lima, A. C. F., Pizauro Júnior, J. M., Macari, M., & Malheiros, E. B. (2003). Efeito do uso de probiótico sobre o desempenho e atividade de enzimas digestivas de frangos de corte. *Revista Brasileira de Zootecnia, 32*(1), 200-207.

Luegas, J. P., Albino, J. T., Tabernari, F., Barros, V. M., Pessoa, G. S., & Rostagno, H. S. (2015). Efeito da adição de probióticos na dieta sobre digestibilidade ileal da materia seca e da proteína de frangos de corte. *Archivos de Zootecnia, 64*(247), 199-204.

Mokhtari, R., Yazdani, A. R., Rezaei, M., & Ghorbani, B. (2010). The effects of different growth promoters on performance and carcass characteristics of broiler chickens. *Journal of Animal and Veterinary Advances, 9*(20), 2633-2639.

Paz, A. S., Abreu, R. D., Costa, M. C. M. M., Jaeger, S. M. P. L., Rocha, A. P., Ferreira, B. P., ... Campos, B. M. (2010). Aditivos promotores de crescimento na alimentação de frangos de corte. *Revista Brasileira de Saúde e Produção Animal, 11*(2), 395-402.

Pedroso, A. A., Menten, J. F., Lambais, M. R., Racanicci, A. M. C., Longo, F. A., & Sorbara, J. O. B. (2006). Intestinal bacterial community and growth performance of chickens fed diets containing antibiotics. *Poultry Science, 85*(4), 747-752.

Pelicano, E. R. L., Souza, P. A., Souza, H. B. A., Oba, A., Norkus, E. A., Kodawara, L. M., & Lima, T. M. A. (2003). Morfometria e ultra-estrutura da mucosa intestinal de frangos de corte alimentados com dietas contendo diferentes probióticos. *Revista Portuguesa de Ciências Veterinárias, 98*(547), 125-134.

Perumalla, A. V. S., Hettiarachchy, N. S., & Ricke, S. C. (2011). Current perspectives on probiotics in poultry preharvest food safety. In T. R. Callaway, & S. C. Ricke (Eds.), *Direct-Fed Microbials and Prebiotics for Animals* (p. 89-120). USA: Springer.

Rigobelo, E. C., Maluta, R. P., & Ávila, F. A. (2011). Desempenho de frangos de corte suplementadas com probiótico. *Ars Veterinaria, 27*(2), 111-115.

Rostagno, H. S., Albino, L. F. T., Donzele, J. L., Gomes, P. C., Oliveira, R., Lopes, D. C., ... Euclides, R. F. (2011). *Composição de alimentos e exigências nutricionais* (3a ed.). Viçosa: Universidade Federal de Viçosa.

Santos Júnior, A. A., Ferket, P. R., Grimes, J. L., & Edens, F. W. (2004). Dietary pentosanase supplementation of diets containing different qualities of wheat on growth performance and metabolizable energy of turkey poults. *International Journal of Poultry Science, 3*(1), 33-45.

Schwarz, S., Kehrenberg, C., & Walsh, T. R. (2001). Use of antimicrobial agents in veterinary medicine and food animal production. *International Journal of Antimicrobial Agents, 17*(6), 431-437.

Stanton, T. B. (2013). A call for antibiotic alternatives research. *Trends in Microbiology, 21*(3), 111-113.

Takahashi, K., Akiba, Y., & Matsuda, A. (1997). Effect of a probiotic on immune responses in broiler chicks under different sanitary conditions or immune activation. *Animal Science and Technology, 68*(6), 537-544.

Yun, W., Lee, D. H., Choi, Y. I., Kim, I. H., & Cho, J. H. (2017). Effects of supplementation of probiotics and prebiotics on growth performance, nutrient digestibility, organ weight, fecal microbiota, blood profile, and excreta noxious gas emissions in broilers. *Journal of Applied Poultry Research, 26*(4), 584-592.

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