KELLY MORAIS MAIA DIAS

EVALUATION OF CORN ETHANOL COPRODUCTS ON BROILERS DIETS

Dissertation submitted to the Animal Science Graduate Program of the Universidade Federal de Viçosa in partial fulfillment of the requirements for the degree of *Magister Scientiae*.

Adviser: Luiz Fernando Teixeira Albino

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To God and to my family.

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"Be fearful when others are greedy and greedy when others are fearful".

(Warren Buffett)

ABSTRACT

DIAS, Kelly Morais Maia, M.Sc., Universidade Federal de Viçosa, February, 2023. **Evaluation of corn ethanol coproducts on broilers diets**. Adviser: Luiz Fernando Teixeira Albino. Co-adviser: Arele Arlindo Calderano.

Experiment 1 aimed to determine nitrogen-corrected apparent metabolizable energy (AMEn) and standardized ileal amino acid digestibility (SIAAD) of two corn ethanol coproducts: high-protein distillers' dried grains (HP-DDG) and corn bran with solubles (CBS). The results showed that AMEn values for HP-DDG and CBS were 3,334 kcal/kg and 2,083 kcal/kg on DM basis, respectively. Concerning the HP-DDG, the digestibility trial resulted in the following SIAAD coefficients and values, respectively: 80.33% and 1.09 for Lys, 85.95% and 1.44 for Met + Cys, 75.58% and 1.24 for Thr, 89.58% and 1.66 for Arg, 84.91% and 1.08 for His, 86.37% and 1.35 for Ile, 90.64% and 4.56 for Leu, 85.76% and 1.80 for Val, and 88.67% and 1.90 for Phe. The digestibility average of HP-DDG is 85.83% for essential amino acids. Concerning the CBS, the following SIAAD coefficients and values were measured, respectively: 79.29% and 0.44 for Lys, 89.57% and 0.31 for Met + Cys, 78.89% and 0.40 for Thr, 92.28% and 0.66 for Arg, 87.48% and 0.36 for His, 93.40% and 0.35 for Ile, 92.27% and 1.01 for Leu, 90.97% and 0.51 for Val, and 88.81% and 0.45 for Phe. The digestibility average of CBS is 88.45% for essential amino acids. Experiment 2 aimed to evaluate the inclusion of HP-DDG in broilers' diets. 1200 Cobb500™ one-day-old male chicks were randomly distributed into 6 treatments with 10 replicates with 20 birds each. The experimental period was divided into three phases: 1) starter, 0 to 21 days old; 2) grower, 22 to 33 days old; and 3) finisher, 34 to 43 days old. The treatments consisted of 6 different inclusion levels of HP-DDG in each phase, respectively: T1) 0% in the starter, grower, and finisher; T2) 3%, 5%, and 7% in the starter, grower, and finisher; T3) 5%, 7%, and 9% in the starter, grower, and finisher; T4) 7%, 9%, and 11% in the starter, grower, and finisher; T5) 9%, 11%, and 13% in the starter, grower, and finisher; and T6) 11%, 13%, and 15% in the starter, grower, and finisher. Body weight (BW), BW gain (BWG), feed intake (FI), and feed conversion ratio (FCR) were measured at 21, 33, and 43 days old. In addition, carcass and cut yields were assessed at 43 days old. Data were submitted to ANOVA and analyzed using Dunnett's Test at 0.05 significance level. Birds fed 11% in the starter phase had lower BW ($P = 0.032$) and BWG ($P = 0.029$)

than the control group, whereas in the finisher phase, birds fed 7 and 9% had lower BWG than control (*P* < 0.005). Overall performance (0 to 43 days) showed no response to the replacement (*P* > 0.05). Carcass and cut yields were not affected by replacing soybean meal for HP-DDG (*P* > 0.05). Therefore, the recommended level for replacement in the starter phase is up to 9%, whereas in the finisher phase is 11, 13, or 15%. Increasing levels according to the rearing phase does not affect overall performance.

Keywords: HP-DDG. Broilers. Performance. Amino acids digestibility. Metabolizable energy.

RESUMO

DIAS, Kelly Morais Maia, M.Sc., Universidade Federal de Viçosa, fevereiro de 2023. **Avaliação de coprodutos de destilaria do milho em rações para frangos de corte**. Orientador: Luiz Fernando Teixeira Albino. Coorientador: Arele Arlindo Calderano.

No experimento 1 objetivou-se determinar a energia metabolizável aparente corrigida para balanço de nitrogênio (EMAn), e a digestibilidade ileal estandardizada de aminoácidos (SIAAD) de dois coprodutos do etanol de milho: os grãos secos de destilaria de alta proteína (HP-DDG) e o farelo de milho com solúveis (CBS). Os resultados para os valores de EMAn do HP-DDG e CBS foram 3.334 kcal/kg e 2.083 kcal/kg da MS, respectivamente. Para o HP-DDG, o ensaio de digestibilidade resultou nos seguintes coeficientes e valores de SIAAD, respectivamente: 80,33% e 1,09 para Lis, 85,95% e 1,44 para Met + Cis, 75,58% e 1,24 para Tre, 89,58% e 1,66 para Arg, 84,91% e 1,08 para His, 86,37% e 1,35 para Ile, 90,64% e 4,56 para Leu, 85,76% e 1,80 para Val e 88,67% e 1,90 para Fen. A digestibilidade média do HP-DDG é de 85,83% para aminoácidos essenciais. Em relação ao CBS, foram determinados os seguintes coeficientes e valores SIAAD, respectivamente: 79,29% e 0,44 para Lis, 89,57% e 0,31 para Met + Cis, 78,89% e 0,40 para Tre, 92,28% e 0,66 para Arg, 87,48% e 0,36 para His, 93,40% e 0,35 para Ile, 92,27% e 1,01 para Leu, 90,97% e 0,51 para Val, e 88,81% e 0,45 para Fen. A digestibilidade média do CBS é de 88,45% para aminoácidos essenciais. O experimento 2 objetivou avaliar a inclusão de HP-DDG em dietas de frangos de corte. 1200 pintos machos Cobb500™ com um dia de idade foram distribuídos aleatoriamente em 6 tratamentos com 10 repetições com 20 aves cada. O período experimental foi dividido em três fases: 1) inicial, 0 a 21 dias de idade; 2) crescimento, 22 a 33 dias; e 3) terminação, 34 a 43 dias de idade. Os tratamentos consistiram em 6 diferentes níveis de inclusão de HP-DDG nas fases inicial, crescimento e terminação, respectivamente: T1) 0%; T2) 3%, 5% e 7%; T3) 5%, 7% e 9%; T4) 7%, 9% e 11%; T5) 9%, 11% e 13%; e T6) 11%, 13% e 15%. O peso corporal (PC), o ganho de peso (GP), o consumo de ração (CR) e a conversão alimentar (CA) foram medidos aos 21, 33 e 43 dias de idade. Além disso, foram avaliados os rendimentos de carcaça e cortes aos 43 dias de idade. Os dados foram submetidos à ANOVA e analisados pelo Teste de Dunnett com nível de significância de 0,05. Aves alimentadas com 11% na fase inicial tiveram menor PC (P = 0,032) e

GP (P = 0,029) do que o grupo controle, enquanto na fase final, aves alimentadas com 7 e 9% tiveram menor PC do que o controle (P < 0,005). De 0 a 43 dias não houve resposta à inclusão (P > 0,05). Os rendimentos de carcaça e cortes não foram afetados pelo HP-DDG (P > 0,05). Portanto, o nível recomendado para reposição na fase inicial é de até 9%, enquanto na fase final é de 11, 13 ou 15%. Aumentar os níveis de acordo com a fase de criação não afeta o desempenho geral.

Palavras-chave: HP-DDG. Frangos de corte. Desempenho. Digestibilidade de aminoácidos. Energia metabolizável.

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SUMMARY

INTRODUCTION

The poultry industry is represented by a series of advances in technology that involve genetics, nutrition, health, environment, and management. These factors contribute to making the poultry industry an important economic and social chain.

Poultry nutrition accounts for about 70% of total production costs, which allows measures aimed at reducing costs to be implemented to improve production efficiency. Moreover, when formulating for poultry it is important not only to the cost but more important is consider how could the animal get all their required nutrients through the diet. Therefore, the knowledge of the composition of ingredients that could be added to the diets is essential.

With a view to reducing the world’s oil dependency, renewable fuel sources have been developed or improved, which have provided an improvement in the nutrient profile of coproducts originating from the process (Shurson, 2018). Among these energy sources are biofuels, which use cereals as raw material for the production of ethanol.

When using corn as a raw material, there are final coproducts, such as distillers’ dried grains (DDG) and distillers’ dried grains with solubles (DDGS). The difference between both coproducts is that the DDGS has the solubles from the process added back to form the final coproduct. Both coproducts have a higher content of protein, fat, and fiber than corn, which is explained by most of the starch present in the corn grain being converted into ethanol during the fermentation process (Salim et al., 2010; Oliveira, 2019).

The incorporation of these coproducts in diets could be a positive factor both in relation to the reduction of production costs, given that coproducts are an alternative in nutrition due to their good protein and mineral composition, as well as environmental factors since their disposal can cause environmental, health and economic disorders (Schöne et al., 2017).

However, the great variability of results found in the literature regarding apparent metabolizable energy (AME) and nitrogen-corrected AME (AMEn), and amino acids digestibility coefficients is among the limiting factors for their use in broilers diets (Rho et al., 2017; Fries-Craft & Bobeck, 2019; Oliveira, 2019). Therefore, is of great interest to standardize these coproducts, which would allow the characterization of their nutritional profiles and their inclusion in broilers’ diets with more precision.

The present study was carried out to determine the AME and amino acids digestibility of corn ethanol coproducts, and to evaluate the inclusion of DDG in broiler diets.

CHAPTER I

NITROGEN-CORRECTED APPARENT METABOLIZABLE ENERGY AND STANDARDIZED ILEAL AMINO ACID DIGESTIBILITY DETERMINATION OF HIGH-PROTEIN DDG AND CORN BRAN WITH SOLUBLES FOR BROILERS

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1. INTRODUCTION

Protein and energy represent a major proportion in poultry diets, so their prices directly influence the cost of poultry production. Therefore, continuous efforts are made to find ingredients that meet broilers' nutritional requirements and reduce feed costs.

Distiller's dried grains (DDG) are a coproduct from the ethanol industry. They have been included in poultry diets due to their potential to partially replace high protein ingredients, such as soybean meal, while reducing the need for supplemental amino acids (AA) (Fries-Craft & Bobeck, 2019). The ethanol industry is characterized by its continuous innovation of processing techniques to enhance ethanol yield, which consequently alters the chemical composition of corn coproducts (Rho et al., 2017).

Fries-Craft & Bobeck (2019) state that intentionally changing the process method can increase the nutritional profile of coproducts, such as increasing crude protein (CP) levels and metabolizable energy (ME), thus increasing their value for non-ruminant animals. Moreover, there is a great interest in producing ethanol coproducts with higher levels of CP content and digestible amino acids for poultry (Corray et al., 2019). Considering this, a recent technology (FST™; ICM Inc., Colwich, KS, USA) was developed that involves the removal of fibers before starch fermentation, which allows ethanol plants to produce more efficiently (Shurson, 2018). It also results in two coproducts: 1) high protein DDG (HP-DDG), which contain ≥ 38% of CP and low fiber levels; and 2) corn bran with solubles (CBS), a high energy coproduct that may vary CP content.

ME is the most common value to define the dietary energy available for poultry. The nitrogen correction for its retention in the body is usually applied to obtain a nitrogen-corrected ME (MEn) (NRC, 1994). At the same time, the standardized ileal amino acid digestibility (SIAAD) of ingredients is essential when formulating poultry diets (Sheikhhasan et al., 2020).

HP-DDG and CBS are limited for broilers' diets due to limited information on their nutritional value. Therefore, the objective of the present study was to determine the nitrogen-corrected apparent metabolizable energy (AMEn) and SIAAD of these two coproducts.

2. MATERIALS AND METHODS

2.1 Ethics Committee

All procedures adopted in this research were previously approved by the Ethics Committee in the Use of Farming Animals at the Federal University of Viçosa under protocol number 034/2021, following the norms of the National Council for Experimentation Animal Control (CONCEA, 2008).

2.2 Birds Husbandry

The experiment was carried out at the Research & Extension Sector for Poultry Production and Nutrition of the Animal Science Department, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.

Cobb500™ male broiler chicks were obtained from a commercial hatchery (Rivelli Alimentos SA, Matheus Leme, MG, Brazil), where all chicks received vaccinations for Marek and Newcastle diseases and infectious bronchitis. Before reaching 16 days, broiler chicks were reared under conditions established by the Cobb500® guideline recommendations. They had free access to water and feed, which was based on corn and soybean meal formulated according to Rostagno et al. (2017).

180 Cobb500™ male chicks (583 g ± 27.8 g) were housed in metabolic cages (600 cm^2/bird) and randomly distributed into 3 treatments, including 10 replicates with six 16-32 day-old birds each. Each experimental unit was equipped with a nipple drinker and a trough feeder to guarantee free access to water and feed during the experimental period. Temperature and light programs were set according to genetic guidelines.

2.3 HP-DDG and CBS

The same batches of HP-DDG and CBS were used in the following experiment and were analyzed for their nutrient profile (Table 1). Both coproducts were sourced from a Brazilian company (F.S. Bioenergia Inc., Lucas do Rio Verde, Mato Grosso, Brazil) and produced through FST™ technology (ICM Inc., Colwich, KS, USA).

2.4 Metabolism Trial – AMEn

The trial was performed from 16 to 26 days old to determine the AMEn. The treatments comprised a basal diet (BD) meeting the nutritional requirements of the birds, according to Rostagno et al. (2017), and two diets composed of 70% of BD and 30% of HP-DDG or CBS (Table 2).

The trial period lasted 10 days; the first 5 days were destined for adapting the birds to the experimental diets, and the last 5 days were intended for total excreta collection and measure of feed intake. A metal tray coated with plastic canvas, which allowed the individual excreta collection for each experimental unit, was placed under the metabolic cages. Excreta were collected twice daily, at 8 a.m. and 4 p.m., to avoid fermentation and nutrient losses. After each collection period, excreta were packed in plastic bags identified according to their respective experimental unit and stored at -20°C. At the end of the last collection day, excreta were defrosted and individually weighed to measure the total amount produced. Feed intake was measured through the difference between the feed given to the birds at the beginning and end of the same 5 collection days.

Homogenous and representative samples of excreta, experimental diets, HP-DDG, and CBS were analyzed according to the Association of Official Analytical Chemists (AOAC): dry matter (DM; AOAC, 934.01, 2006) and nitrogen (N; AOAC, 990.03, 2006). Gross energy (GE) was measured by a C500 adiabatic bomb calorimeter (IKA-Werke GmbH & Co. KG, Staufen, Germany). Nitrogen balance (NB) was calculated by the difference between N intake and N excreted. The total AMEn intake of each experimental diet was calculated using the following equation:

$$AMEn = [(GE\ intake - GE\ excretion) - 8.22 \times NB)] / DM\ intake$$

The equation below was used to calculate the AMEn of HP-DDG and CBS:

$$AMEn = AMEn\ (BD) + [(AMEn\ (TD) - AMEn\ (BD) / g/g\ of\ substitution]$$

Where AMEn (BD) is the nitrogen-corrected metabolizable energy of the basal diet, and AMEn (TD) is nitrogen-corrected metabolizable energy of each of the experimental diets with HP-DDG and CBS.

2.5 Digestibility Trial – SIAAD

The trial was performed from 27 to 32 days old to determine the SIAAD. The treatments comprised a nitrogen-free diet (NFD) used to measure basal ileal endogenous amino acids losses (IEAA), and two diets with 30% of either HP-DDG or CBS replacing starch in the NFD. All diets included 1% of acid insoluble ash (AIA; Celite™) as an indigestible marker (Table 2).

Birds were fed with the experimental diets for 5 days, at the end of which they were slaughtered by cervical dislocation for ileal digesta collection. Ileum was identified as the section of the intestine between Meckel's diverticulum and the ileocecal junction. Digesta were entirely removed by flushing with distilled water. They were placed in plastic pots identified according to their respective experimental unit and stored at -20°C. For the analyses, digesta were lyophilized and grounded. Samples of digesta and diets were analyzed for DM, ash, and AIA content. Moreover, HP-DDG, CBS, diets, and digesta were analyzed for AA and CP content by CBO Análises Laboratoriais (Valinhos, São Paulo, Brazil).

Apparent and standardized digestibility coefficients and endogenous ileal losses were calculated using the following equations:

AIAAD coefficient (%) = [(AA diet (DM, %) / AIA diet (%)) – (AA digesta (%) – AIA digesta (%)) x 100] / (AA diet (DM, %) / AIA diet (%))

IEAA (g/kg DM) = (AA digesta (g/kg DM)) x (AIA diet (g/ kg DM)) / (AIA digesta (g/ kg DM))

SIAAD coefficient (%) = AIAAD coefficient (%) + (IEAA (g/ kg DM) / AA diet (g/ kg DM) x 100

Where AIAAD coefficient is the apparent ileal amino acid digestibility coefficient, IEAA is the ileal endogenous amino acid losses, and SIAAD coefficient is the standardized ileal amino acid digestibility coefficient.

The SIAAD was calculated by multiplying each SIAAD coefficient by the respective AA content in each ingredient.

3. RESULTS AND DISCUSSION

The analyzed composition of CBS is shown in Table 1. The AMEn of CBS was 2,083 kcal/kg on a DM basis (Table 3). This value is lower than the ones observed by Rochell et al. (2011) and Oliveira (2019), who found an AMEn of 3,030 kcal/kg and 2,590 kcal/kg on a DM basis for corn bran and CBS, respectively. Moreover, it is lower than the value of 2,666 kcal/kg on DM basis for conventional DDGS according to the NRC (1994). This lower AMEn value could be explained by the lower fat content and higher NDF levels than those mentioned before (NRC, 1994; Rochell et al., 2011; Oliveira, 2019). The CP of CBS was 17.62% on a DM basis, which is similar to the report from Oliveira (2019), who found a value of 17.44% on a DM basis. However, it is higher than the value of 15.17% found by Rochell et al. (2011) and lower than the conventional DDGS of 29.5% reported by the NRC (1994). In addition, the total Lys concentration in CBS was lower than reported by Oliveira (2019) and conventional DDGS reported by the NRC (1994) (0.55% vs. 0.80% and 0.81% on a DM basis, respectively). Although SIAAD coefficients for CBS displayed a higher value for all essential amino acids than the one reported by Oliveira (2019) and the NRC (1994) for conventional DDGS, the total amino acid concentration was lower. However, the SIAAD of all essential amino acids was similar to the CBS reported by Oliveira (2019) and lower than conventional DDGS reported by the NRC (1994). In summary, the results obtained for CBS in the present study suggest that its energy is lower than previously reported for CBS, corn bran, and conventional DDGS. However, its protein and digestible amino acids are similar to previously reported data on CBS and lower than those on corn bran and conventional DDGS.

The other final ethanol coproduct evaluated was HP-DDG and its analyzed composition is shown in Table 1. The AMEn of HP-DDG was 3,334 kcal/kg on a DM basis (Table 3), which is similar to the value of 3,276 kcal/kg reported by Fries-Craft & Bobeck (2019), and higher than value of 2,546 kcal/kg reported by Oliveira (2019). Due to the high CP content (46.44% on a DM basis), HP-DDG was expected to contain higher levels of all amino acids than conventional DDGS. For example, the total Lys content in HP-DDG was 1.36%, whereas conventional DDGS contain 0.81% (NRC, 1994). Lys, Met, and Thr are among the most limiting AA in broiler nutrition; therefore, a high digestibility of these AA in HP-DDG would be of great interest. The total AA content was higher or similar to the ones reported by Jung & Batal (2009) and Fries-

Craft & Bobeck (2019), but lower than the content in Lys and Thr, reported by Oliveira (2019). The SIAAD coefficients showed a similar pattern to those reported by Jung & Batal (2009) and Fries-Craft & Bobeck (2019), which were higher than those reported by Oliveira (2019). In general, the results found for SIAAD are in agreement with the previous reports in the literature for the essential amino acids assessed (Jung & Batal, 2009; Fries-Craft & Bobeck, 2019; Oliveira, 2019). In addition, the SIAAD of Met + Cys and Thr in HP-DDG were similar, but they were lower in Lys compared to soybean meal with 44% of CP (Rostagno et al., 2017). On the other hand, the SIAAD of Lys and Thr were lower in HP-DDG, but the one of Met was higher compared to soybean meal with 44% of CP, as reported in the NRC (1994). Overall, the nutritional value of HP-DDG used in this study is consistent with previous research regarding AMEn and SIAAD.

4. CONCLUSION

The AMEn of CBS and HP-DDG is 2,083.94 kcal/kg and 3,334.30 kcal/kg on a DM basis, respectively. The digestibility average of CBS is 88.45% for essential amino acids and 85.21% for non-essential amino acids, whereas the digestibility average of HP-DDG is 85.83% for essential amino acids and 83.83% for non-essential amino acids.

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CHAPTER II

EFFECTS OF DIFFERENT LEVELS OF CORN HIGH-PROTEIN DISTILLERS' DRIED GRAINS ON BROILERS PERFORMANCE

Kelly M. M. Dias[a], Carlos H. Oliveira[a], Ideraldo L. Lima[b], Arele A. Calderano[a], Horácio S. Rostagno[a], Luiz F. T. Albino[a].

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1. INTRODUCTION

The desire of reducing the world's dependence on oil together with the depletion of fossil fuel reserves have led to significant research efforts in the development of renewable energy sources. In response to this, ethanol production has grown widely around the world, including corn-based ethanol, which increases the availability of distillers' dried grain (DDG) for use in animals' feed (Kumar & Singh, 2019).

Many ethanol plants are frequently improving processing techniques. The fiber separation technology (FST™; ICM Inc., Colwich, KS, USA) is applied before starch fermentation aiming the removal of fiber content. Therefore, improving ethanol yield and resulting in a coproduct that contains higher crude protein (CP) levels, a high-protein DDG (HP-DDG), than conventional distillers' dried grains with solubles (DDGS) (Applegate et al., 2009; Shurson, 2018). Although HP-DDG contains high levels of protein, amino acids, energy, and minerals, its composition may vary due to the processing used, then the inclusion of HP-DDG in broilers' diets depends on its nutrient and energy availability (Silva et al., 2022).

The inclusion of DDGS in broilers' diets is well documented. High inclusion levels of DDGS are reported to reduce growth performance, probably because of its high fiber content (Lumpkins et al., 2004; Wang et al., 2008; Loar et al., 2010; Cuevas et al., 2012; Loar et al., 2012; Zhang et al., 2013). On the other hand, the inclusion of HP-DDG in greater amounts could be possible without impairing the performance, which would be an alternative to high-protein ingredients, such as soybean meal (Jung & Batal, 2010; Fries-Craft & Bobeck, 2019). However, few studies documented the use of HP-DDG for broiler chickens.

We hypothesized that different inclusion levels of HP-DDG would not impair broiler performance. Therefore, the present study objective was to evaluate the effect of HP-DDG on birds' performance.

2. MATERIALS AND METHODS

2.1 Ethics Committee

All procedures adopted in this research were previously approved by the Ethics Committee in the Use of Farming Animals at the Federal University of Viçosa under protocol number 034/2021, following the norms of the National Council for Experimentation Animal Control (CONCEA, 2008)..

2.2 Birds Husbandry

T The experiment was carried out at the Research & Extension Sector for Poultry Production and Nutrition of the Animal Science Department, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.

Cobb500™ male broiler chicks were obtained from a commercial hatchery (Rivelli Alimentos SA, Matheus Leme, MG, Brazil), where all chicks received vaccinations for Marek and Newcastle diseases and infectious bronchitis.

The same batch of HP-DDG was used in the present study and was analyzed for its nutrient profile (Table 1). The coproduct was sourced from a Brazilian company (F.S. Bioenergia Inc., Lucas do Rio Verde, Mato Grosso, Brazil) and produced through FST™ technology (ICM Inc., Colwich, KS, USA).

A total of 1,200 Cobb500™ one-day-old male chicks (47.3 g ± 2.43 g) were weighed and randomly distributed into 6 treatments with 10 replicates with 20 birds each. Birds were reared in floor pens covered with fresh wood shaving and equipped with one tubular feeder and 5 in-line nipple drinkers. Experimental diets and water were given ad libitum during the whole experimental period. Temperature and light programs were set according to genetic guidelines.

2.3 Experimental Period and Diets

The experimental period was divided into three phases: 1) starter, 0 to 21 days old; 2) grower, 22 to 33 days old; and 3) finisher, 34 to 43 days old. Diets were isoenergetic and isonutritive, based on corn and soybean meal and formulated according to Rostagno et al. (2017) to meet all nutritional requirements in each phase. The treatments were determined through different inclusion levels of HP-DDG in each phase (Table 4).

Two basal diets were formulated for each phase, one without and another with the maximum inclusion of HP-DDG (Table 5), and a dilution of both diets was made to achieve the established levels for the treatments (Table 6).

2.4 Broiler Performance and Carcass Yield

Birds, feed, and leftover feed were individually weighed at days 0, 21, 33, and 43 to determine body weight (BW, kg/bird), body weight gain (BWG, kg/bird), feed intake (FI, kg/bird) and feed conversion ratio (FCR, kg/kg). In case of broiler mortality, the animal was removed from its experimental unit and the feed was weighed to correct FI.

At 43 days, two birds per replicate, with the closest BW to the average, were selected and withdrawn from feed, totaling 12 hours. After that, birds were slaughtered to measure carcass and cuts yield. After the removal of the feather, viscera, head, neck, and feet, the carcasses were weighed, and their weight was divided by the birds' live weight to determine carcass yield (CY, %). Afterward, breast (BY, %), wing (WY, %), drumstick (DY, %), and thigh (TY, %) were removed and weighed to determine their respective yields.

2.5 Statistical Analysis

Data were analyzed by one-way ANOVA using Exp.Des.pt from the R statistical R package (R software v.4.0.4). Dunnett's test ($P \leq 0.05$) was used to compare each variable from treatments containing HP-DDG to the treatment without its inclusion.

3. RESULTS AND DISCUSSION

The increase in HP-DDG levels in the respective rearing phases showed an effect during the starter and finisher phases (Table 7). In the starter phase, only birds fed 11% of HP-DDG had 3% lower BWG ($P = 0.032$) and 2.8% lower BW ($P = 0.029$) than those from the control treatment. In the finisher phase, birds fed 7 and 9% of HP-DDG showed 5.8% lower BWG ($P < 0.005$) than the control treatment. However, when analyzing the overall performance (0 to 43 days), there were no effects observed ($P > 0.05$). In addition, the carcass and cuts yields were not affected by treatments ($P > 0.05$) (Table 8).

The results from the starter phase are in agreement with Fries-Craft & Bobeck (2019) since the authors have not reported differences in broiler performance when they were fed 10% HP-DDG compared to those from the control group. However, the inclusion of 15% of HP-DDG in the starter phase reduced 10% BW, 8.8% BWG, and increased 9.4% FCR. Our findings suggested that until reaching the level of 9% HP-DDG, the performance of broilers remained similar to the control group, and the inclusion of 11% HP-DDG showed detrimental effects. On the other hand, Jung & Batal (2010) reported no differences in broilers' performance when fed HP-DDG up to 16% during the starter phase. Similarly, Oliveira (2020) reported no influence of replacing soybean meal for HP-DDG up to 30% in the starter phase. The starter phase is crucial for the development of the skeletal structure and gastrointestinal tract of chicks, which can directly affect their growth. Fries-Craft & Bobeck (2019) associated the poor performance in the grower and finisher phases, and the overall period with the reduction in performance observed in the starter phase. However, our results showed that birds with lower BW and BWG in the starter phase did not have performance impairment in the next rearing phases, and overall period.

Conversely, in the finisher phase, there is a report that higher inclusions of HP-DDG or impaired broilers' weight gain (Fries-Craft & Bobeck, 2019) or did not affect it (Oliveira, 2020). However, in the present study, we found that lower levels of HP-DDG inclusion negatively affected BWG, which was recovered when increasing the levels. Although BWG was affected in the finisher phase, the FCR did not show differences, which is in contrast to results reported previously (Fries-Craft & Bobeck, 2019; Oliveira, 2020).

The inclusion of HP-DDG up to 16% decreased the performance of broiler chickens from 0 to 33 days old when compared to the control group without its inclusion (Jung & Batal, 2010). Moreover, it was reported that 15 and 20% of HP-DDG negatively affected performance parameters in the grower phase (Fries-Craft & Bobeck, 2019). These findings diverge from the results from the present study, where increasing levels of HP-DDG in the starter and grower phases had no negative effect when evaluating the period of 0 to 33 days old. In addition, Oliveira (2020) reported no effect of HP-DDG inclusion up to 30% in broilers' diets from 22 to 35 days old, which is similar to our findings.

Overall, HP-DDG inclusion was not reported to affect broilers' performance from 0 to 42 (Applegate et al., 2009; Oliveira, 2020), except for the study reported by Fries-Craft & Bobeck (2019). In the latter, the authors state that a poor performance linked to HP-DDG inclusion is associated with its amino acid content. They observed that increasing levels of HP-DDG decreased Lys, and Met + Cys in the diets, leading to a deficiency (Jung & Batal, 2010). Therefore, there is a need for supplemental amino acids, especially Lys, when replacing soybean meal for HP-DDG. In the present study, the diets were formulated taking into consideration this need for supplemental amino acids, which could explain why we did not find any negative effects on overall performance.

Furthermore, the different inclusion levels of HP-DDG in each phase were calculated taking into consideration the fiber levels. Fiber could impair broilers' growth by decreasing nutrients' digestibility, especially in the starter phase. This could explain the difference between the results reported in the literature, in which the high levels of inclusion may elevate fiber content in the diets, negatively affecting performance. The gradual increase in HP-DDG in the respective treatments in each rearing phase could have conditioned the digestive tract of birds' since the starter phase, thus helping when included higher levels of HP-DDG. Therefore, fiber should be taken into consideration when adding HP-DDG to diets. In addition, HP-DDG and soybean meal used in the present study had a similar crude protein content, which could have reduced the impact of the replacement.

The results regarding the carcass and cuts yield followed the performance results, thus, showing no differences and in accordance with the previous report by Oliveira (2020). Although Cordeiro (2018) reported that HP-DDG inclusion up to 30% did not affect cuts yields, it affected carcass yield, which showed a quadratic effect in which the inclusion level of 8.38% promoted greater carcass yield.

4. CONCLUSION

The inclusion of HP-DDG up to 9% in replacement of soybean meal from 0 to 21 days does not show detrimental effects on the performance parameters of broiler chickens. In addition, from 34 to 43 days is recommended the inclusion levels of 11, 13, or 15% of HP-DDG. Analyzing the overall period from 0 to 43 days, the replacement of soybean meal for HP-DDG, regardless of the level assessed (3 to 15%), is efficient in maintaining broilers' performance.

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CONCLUSION

The AMEn for the CBS is 2,083 kcal/kg on DM basis, and for HP-DDG is 3,334 kcal/kg on DM basis.

Regarding the SIAAD, the average digestibility of essential amino acids of CBS is 88.45%, whereas of nonessential amino acids is 85.21%. On the other hand, the average digestibility of essential amino acids of HP-DDG is 85.83%, whereas of nonessential amino acids is 83.83%.

The recommendation inclusion of HP-DDG is up to 9% from 1 to 21 days, and 11, 13 or 15% from 34 to 43 days. Increasing levels of HP-DDG (3 to 15%) in the respective rearing phases, from 1 to 43 days, neither impair overall broiler performance nor carcass and cuts yields.

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Table 1. Analyzed composition of HP-DDG and CBS used in the metabolism and digestibility trials, as fed-basis.

	HP-DDG	CBS
Dry matter, %	91.48	88.76
Crude protein, %	42.03	15.64
Gross energy, kcal/kg	5,358.0	4,293.0
Ether extract, %	13.03	6.15
Starch, %	5.48	3.45
Crude fiber, %	6.06	10.78
Neutral detergent fiber, %	24.14	49.86
Acid detergent fiber, %	16.88	12.74
Ash, %	2.21	5.44
Calcium, %	0.005	0.00
Total phosphorus, %	0.49	0.70
Sodium, %	0.07	0.18
Magnesium, %	0.10	0.30
Potassium, %	0.56	1.48
Copper, mg/kg	10.42	6.26
Iron, mg/kg	157.57	52.13
Manganese, mg/kg	6.23	17.81
Zinc, mg/kg	49.76	67.24
Lysine	1.36	0.55
Methionine	0.91	0.17
Methionine + Cystine	1.68	0.35
Threonine	1.64	0.51
Arginine	1.85	0.72
Histidine	1.27	0.41
Isoleucine	1.56	0.38
Leucine	5.03	1.09
Valine	2.1	0.56
Phenylalanine	2.14	0.51
Alanine	3.27	0.92
Aspartic acid	2.78	0.87
Cystine	0.77	0.18
Glutamic acid	7.51	1.96
Glycine	1.66	0.66
Serine	2.12	0.60
Glycine + Serine	3.78	1.26
Tyrosine	1.71	0.40
Phenylalanine + Tyrosine	3.85	0.91
Proline	3.89	1.10

Table 2. Composition of the experimental diets used the metabolism and digestibility trials.

Ingredients, %			
	Metabolism Trial		
	Basal diet	**30% HP-DDG**	**30% CBS**
Corn	60.15	42.11	42.11
Soybean meal	35.00	24.50	24.50
Soybean oil	2.10	1.47	1.47
Dicalcium phosphate	0.95	0.67	0.67
Limestone	0.98	0.69	0.69
Salt	0.48	0.34	0.34
Mineral Premix[1]	0.05	0.04	0.04
Vitaminic Premix[2]	0.13	0.09	0.09
Choline chloride, 60%	0.10	0.07	0.07
Salinomycin, 12%	0.05	0.04	0.04
BHT[3]	0.01	0.01	0.01
High-protein DDG	-	30.00	-
Corn bran with solubles	-	-	30.00
Total	**100.00**	**100.00**	**100.00**
	Digestibility Trial		
	NFD	**30% HP-DDG**	**30% CBS**
Starch	82.75	52.75	52.75
Sugar	5.00	5.00	5.00
Soybean oil	5.00	5.00	5.00
Dicalcium phosphate	1.62	1.62	1.62
Limestone	0.80	0.80	0.80
Salt	0.45	0.45	0.45
Corncob	3.00	3.00	3.00
Mineral Premix[1]	0.05	0.05	0.05
Vitaminic Premix[2]	0.13	0.13	0.13
Choline chloride, 60%	0.20	0.20	0.20
Indigestible marker Celite™	1,00	1,00	1,00
High-protein DDG	-	30.00	-
Corn bran with solubles	-	-	30.00
Total	**100.00**	**100.00**	**100.00**

[1]Trace mineral premix provided per kg of diet: Mn, 58.36 g; Fe, 41.68 g; Zn, 54.21 g; Cu, 8.31 g; I, 0.84 g; Se, 0.25 g.

[2]Vitamin premix provided per kg of diet: vitamin A, 9,638,000 IU; vitamin D3, 2,410,000 IU; vitamin E, 36,100 IU; vitamin B1, 2.60 g; vitamin B2, 6.45 g; vitamin B6, 3.61 g; vitamin B12, 15.9 mg; vitamin K3, 1.94 g; pantothenic acid, 12.95 g; nicotinic acid, 39.20 g; folic acid, 0.90 g; biotin, 89.80 mg.

[3]Antioxidant Butylhydroxytoluene.

Table 3. Apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), standardized ileal amino acid digestibility coefficient (SIAAD coef.), total amino acids content (AA), standardized ileal digestibility (SID), and ileal endogenous amino acids losses (IEAA) of HP-DDG and CBS used in the metabolism and digestibility trials.

	HP-DDG			**CBS**			
	AME, kcal/kg	**AMEn, kcal/kg**		**AME, kcal/kg**	**AMEn, kcal/kg**		**IEAA, g/kg DM**
Dry matter	3,535 ± 410.3	3,334 ± 399.1		2,215 ± 536.5	2,083 ± 478.6		
Natural matter	3,243 ± 376.4	3,058 ± 366.1		1,966 ± 448.9	1,849 ± 424.8		
	SIAAD coef. (%)	**AA, %**	**SID[1]**	**SIAAD coef. (%)**	**AA, %**	**SID[1]**	
Essential Amino acids							
Lysine	80.33 ± 4.285	1.36	1.09	79.29 ± 7.815	0.55	0.44	0.408 ± 0.1924
Methionine	90.54 ± 3.380	0.91	0.82	91.50 ± 4.275	0.17	0.16	0.106 ± 0.0433
Methionine + Cystine	85.95 ± 3.845	1.68	1.44	89.57 ± 3.775	0.35	0.31	0.167 ± 0.0642
Threonine	75.58 ± 5.869	1.64	1.24	78.89 ± 11.219	0.51	0.40	0.611 ± 0.1894
Arginine	89.58 ± 3.640	1.85	1.66	92.28 ± 3.755	0.72	0.66	0.379 ± 0.1585
Histidine	84.91 ± 3.550	1.27	1.08	87.48 ± 3.926	0.41	0.36	0.190 ± 0.0832
Isoleucine	86.37 ± 4.870	1.56	1.35	93.40 ± 5.373	0.38	0.35	0.379 ± 0.1276
Leucine	90.64 ± 3.484	5.03	4.56	92.27 ± 3.747	1.09	1.01	0.631 ± 0.2420
Valine	85.76 ± 4.587	2.10	1.80	90.97 ± 4.338	0.56	0.51	0.478 ± 0.1839
Phenylalanine	88.67 ± 3.926	2.14	1.90	88.81 ± 6.369	0.51	0.45	0.338 ± 0.1242
Nonessential Amino acids							
Alanine	88.03 ± 3.907	3.27	2.88	87.87 ± 4.193	0.92	0.81	0.420 ± 0.1613
Aspartic acid	77.73 ± 5.289	2.78	2.16	85.38 ± 6.186	0.87	0.74	0.301 ± 0.1189
Cystine	79.26 ± 4.634	0.77	0.61	86.67 ± 4.543	0.18	0.16	0.061 ± 0.0213
Glutamic acid	88.86 ± 2.228	7.51	6.67	91.09 ± 3.977	1.96	1.79	0.653 ± 0.2878
Glycine	75.37 ± 4.691	1.66	1.25	78.44 ± 6.808	0.66	0.52	0.464 ± 0.1492
Serine	80.47 ± 4.451	2.12	1.71	74.88 ± 10.049	0.60	0.45	0.539 ± 0.1681
Glycine + Serine	78.23 ± 4.527	3.78	2.96	76.92 ± 8.029	1.26	0.97	1.003 ± 0.3168
Tyrosine	88.57 ± 3.892	1.71	1.51	88.46 ± 5.288	0.40	0.35	0.299 ± 0.1075
Phenylalanine + Tyrosine	94.74 ± 2.009	3.85	3.65	95.16 ± 2.177	0.91	0.87	0.325 ± 0.1084
Proline	87.03 ± 2.175	3.89	3.39	87.27 ± 3.555	1.10	0.96	0.497 ± 0.1476

AME, AMEn, SIAAD and IEAA presented as average of 10 replicates cages ± standard deviation.

[1]SID = (total amino acids concentration x standardized digestibility coefficient) / 100

Table 4. Description of treatments with the levels of HP-DDG included in the experimental diets according to the period.

Treatment	**Starter**	**Grower**	**Finisher**
T1	0	0	0
T2	3	5	7
T3	5	7	9
T4	7	9	11
T5	9	11	13
T6	11	13	15

Table 5. Experimental diet formulations used in the starter (1 to 21 days), grower (22 to 33 days), and finisher (34 to 43 days) phases.

Ingredient %	Starter		Grower		Finisher	
	0% HP-DDG	**11% HP-DDG**	**0% HP-DDG**	**13% HP-DDG**	**0% HP-DDG**	**15% HP-DDG**
Corn	52.07	50.09	57.47	53.12	63.69	57.04
Soybean meal	41.18	32.64	35.05	26.63	29.74	21.45
HP-DDG	0.00	11.00	0.00	13.00	0.00	15.00
Soybean oil	3.05	2.49	4.23	3.93	3.80	3.75
Dicalcium phosphate	1.24	1.04	0.93	0.68	0.54	0.25
Limestone	1.01	1.21	0.79	1.02	0.76	1.02
Salt	0.52	0.50	0.49	0.47	0.46	0.44
DL-Methionine, 99%	0.32	0.27	0.27	0.20	0.23	0.14
L-Lysine HCl, 98,5%	0.14	0.28	0.28	0.49	0.31	0.47
L-Threonine, 98%	0.05	0.05	0.04	0.02	0.03	0.00
Mineral premix[1]	0.13	0.13	0.13	0.13	0.13	0.13
Vitamin premix[2]	0.13	0.13	0.13	0.13	0.13	0.13
Choline chloride, 60%	0.10	0.10	0.10	0.10	0.10	0.10
Salinomycin, 12%	0.06	0.06	0.06	0.06	0.06	0.06
Phytase 50g/ton	0.01	0.01	0.01	0.01	0.01	0.01
BHT[3]	0.01	0.01	0.01	0.01	0.01	0.01
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated composition						
Crude protein, %	23.24	23.86	20.89	22.14	18.96	20.86
Metabolizable energy, kcal/kg	3,000	3,000	3,150	3,150	3,200	3,200
Calcium, %	0.937	0.937	0.758	0.758	0.634	0.634
Available phosphorus, %	0.440	0.440	0.374	0.374	0.296	0.296
Sodium, %	0.218	0.218	0.208	0.208	0.197	0.197
Potassium, %	0.923	0.823	0.829	0.735	0.752	0.664
Chlorine, %	0.374	0.358	0.362	0.342	0.349	0.325
Linoleic acid, %	2.873	2.597	3.560	3.393	3.417	3.362
SID Lys, %	1.256	1.256	1.124	1.124	1.014	1.014
SID Met, %	0.624	0.598	0.554	0.516	0.492	0.443
SID Met + Cys, %	0.929	0.929	0.832	0.832	0.750	0.750
SID Thr, %	0.829	0.829	0.742	0.742	0.669	0.676
SID Trp, %	0.267	0.246	0.235	0.219	0.208	0.197
SID Ile, %	0.905	0.862	0.803	0.779	0.718	0.713
SID Leu, %	1.770	1.907	1.630	1.826	1.521	1.777
SID Arg, %	1.458	1.349	1.286	1.203	1.142	1.085
SID Val, %	0.967	0.970	0.865	0.896	0.781	0.839
SID Gly + Ser, %	1.871	1.846	1.669	1.693	1.503	1.575
SID His, %	0.557	0.566	0.504	0.528	0.461	0.500
SID Phe, %	1.048	1.033	0.936	0.948	0.845	0.882
SID Phe + Tyr, %	1.853	1.849	1.659	1.704	1.499	1.594

[1]Trace mineral premix provided per kg of diet: Mn, 58.36 g; Fe, 41.68 g; Zn, 54.21 g; Cu, 8.31 g; I, 0.84 g; Se, 0.25 g.
[2]Vitamin premix provided per kg of diet: vitamin A, 9,638,000 IU; vitamin D3, 2,410,000 IU; vitamin E, 36,100 IU; vitamin B1, 2.60 g; vitamin B2, 6.45 g; vitamin B6, 3.61 g; vitamin B12, 15.9 mg; vitamin K3, 1.94 g; pantothenic acid, 12.95 g; nicotinic acid, 39.20 g; folic acid, 0.90 g; biotin, 89.80 mg.
[3]Antioxidant Butylhydroxytoluene.

Table 6. Proportions established for the dilution of the two basal diets to form the experimental treatments for the starter (1 to 21 days), grower (22 to 33 days), and finisher (34 to 43 days) phases.

	Starter					
HP-DDG level	**0%**	**3%**	**5%**	**7%**	**9%**	**11%**
0% HP-DDG	100	72,73	54,55	36,36	18,18	0,00
11% HP-DDG	0,00	27,27	45,45	63,64	81,82	100
Total	100	100	100	100	100	100
	Grower					
HP-DDG level	**0%**	**5%**	**7%**	**9%**	**11%**	**13%**
0% HP-DDG	100	61,54	46,15	30,77	15,38	0
13% HP-DDG	0	38,46	53,85	69,23	84,62	100
Total	100	100	100	100	100	100
	Finisher					
HP-DDG level	**0%**	**7%**	**9%**	**11%**	**13%**	**15%**
0% HP-DDG	100	53,33	40,00	26,67	13,33	0
15% HP-DDG	0	46,67	60,00	73,33	86,67	100
Total	100	100	100	100	100	100

Table 7. Feed intake (FI), body weight gain (BWG), body weight (BW), and feed conversion ratio (FCR) of broiler fed different levels of HP-DDG from 1 to 43 days old.

	Treatments						*p-value*	SEM
	Starter – 1 to 21 days							
	0%	3%	5%	7%	9%	11%		
FI, kg/bird	1.364	1.383	1.359	1.372	1.359	1.371	0.881	0.006
BWG, kg/bird	1.083	1.093	1.073	1.060	1.063	1.050*	0.032	0.004
BW, kg/bird	1.129	1.139	1.119	1.107	1.109	1.097*	0.029	0.004
FCR, kg/kg	1.260	1.265	1.267	1.294	1.279	1.306	0.085	0.005
	Grower – 22 to 33 days							
	0%	5%	7%	9%	11%	13%		
FI, kg/bird	1.974	1.978	2.010	1.995	1.993	1.988	0.586	0.006
BWG, kg/bird	1.285	1.283	1.319	1.281	1.303	1.291	0.105	0.005
BW, kg/bird	2.414	2.422	2.457	2.388	2.412	2.387	0.050	0.007
FCR, kg/kg	1.540	1.543	1.524	1.559	1.531	1.543	0.649	0.006
	Finisher – 34 to 43 days							
	0%	7%	9%	11%	13%	15%		
FI, kg/bird	2.187	2.141	2.152	2.166	2.166	2.184	0.824	0.011
BWG, kg/bird	1.159	1.091*	1.093*	1.164	1.139	1.149	< 0.005	0.007
BW, kg/bird	3.574	3.513	3.549	3.552	3.551	3.356	0.332	0.008
FCR, kg/kg	1.886	1.966	1.969	1.861	1.903	1.905	0.051	0.012
	1 to 33 days							
FI, kg/bird	3.338	3.360	3.369	3.366	3.351	3.359	0.954	0.010
BWG, kg/bird	2.368	2.375	2.393	2.342	2.365	2.341	0.166	0.007
BW, kg/bird	2.414	2.422	2.467	2.388	2.412	2.387	0.050	0.007
FCR, kg/kg	1.410	1.415	1.409	1.438	1.418	1.436	0.224	0.004
	1 to 43 days							
FI, kg/bird	5.525	5.501	5.521	5.532	5.517	5.543	0.985	0.016
BWG, kg/bird	3.527	3.467	3.486	3.505	3.504	3.489	0.253	0.007
BW, kg/bird	3.574	3.513	3.549	3.552	3.551	3.536	0.332	0.008
FCR, kg/kg	1.567	1.587	1.585	1.578	1.575	1.588	0.694	0.004

*Means followed by an asterisk differ from the control treatment (T1) by Dunnett's test (α = 0.05).
T1: starter, 0% HP-DDG; grower, 0% HP-DDG; finisher, 0% HP-DDG. T2: starter, 3% HP-DDG; grower, 5% HP-DDG; finisher, 7% HP-DDG. T3: starter, 5% HP-DDG; grower, 7% HP-DDG; finisher, 9% HP-DDG. T4: starter, 7%; grower, 9% HP-DDG, finisher, 11% HP-DDG. T5: starter, 9% HP-DDG; grower, 11%; finisher, 13% HP-DDG. T6: starter, 11% HP-DDG; grower, 13%; finisher, 15% HP-DDG.
SEM: standard error of the mean.

Table 8. Carcass yield (CY), breast yield (BY), wings yield (WY), drumstick yield (DY), and thigh yield (TY) of broiler chickens fed different levels of HP-DDG at 43 days old.

	T1	T2	T3	T4	T5	T6	*p-value*	SEM
CY, %	79.74	79.70	79.21	80.04	80.87	79.40	0.530	0.261
BY, %	34.65	34.73	34.77	33.68	34.67	34.48	0.681	0.209
WY, %	9.41	9.61	9.56	9.47	9.48	9.55	0.852	0.046
DY, %	14.71	14.80	14.65	14.67	14.69	14.93	0.965	0.094
TY, %	12.72	12.59	12.66	12.85	12.66	12.69	0.930	0.068

T1: starter, 0% HP-DDG; grower, 0% HP-DDG; finisher, 0% HP-DDG. T2: starter, 3% HP-DDG; grower, 5% HP-DDG; finisher, 7% HP-DDG. T3: starter, 5% HP-DDG; grower, 7% HP-DDG; finisher, 9% HP-DDG. T4: starter, 7%; grower, 9% HP-DDG, finisher, 11% HP-DDG. T5: starter, 9% HP-DDG; grower, 11%; finisher, 13% HP-DDG. T6: starter, 11% HP-DDG; grower, 13%; finisher, 15% HP-DDG.
SEM: standard error of the mean.

UNIVERSIDADE FEDERAL DE VIÇOSA
COMISSÃO DE ÉTICA NO USO DE ANIMAIS DE PRODUÇÃO
CEUAP/UFV

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Viçosa, 15 de Jul, de 2021

CERTIFICADO

Certificamos que o projeto intitulado **"Avaliação dos grãos secos de destilaria (DDG) no desempenho de frangos de corte e determinação dos coeficientes de digestibilidade de aminoácidos e dos valores de energia metabolizável"**, protocolo **nº 034/2021**, sob a responsabilidade de **Luiz Fernando Teixeira Albino** - que envolve a produção, manutenção e/ou utilização de animais pertencentes ao filo chordata, subfilo vertebrata (exceto o homem), para fins de pesquisa científica (ou ensino) - encontra-se de acordo com os preceitos da lei nº 11.794, de 8 de outubro de 2008, do decreto nº 6.899, de 15 de julho de 2009, e com as normas editadas pelo Conselho Nacional de Controle da Experimentação Animal (CONCEA), e foi apreciado pela Comissão de Ética no Uso de Animais de Produção da Universidade Federal de Viçosa (CEUAP-UFV) em reunião de **09 de Julho de 2021.**

Finalidade: (**x**)**Pesquisa** ( )**Ensino** Vigência do Projeto: de **03 de Ago. 2021** a **03 de Mar. 2022**
Espécie/linhagem: **Frango de corte** ***(Gallus domesticus)*** Nº de animais: **1810**
Peso: **0,04 Kg** Idade: **1 dia** Sexo: **Macho** Origem: **Incubatorio Rivelli CNPJ/CPF: 478.715.616-49**
Endereço: Rua Leão José, 257 Mateus Leme, MG Responsável : Maria Cecília CRMV: 10595

CERTIFICATE

We certify that the project entitled **"Evaluation of distillers dried grains (DDG) on growth performance in broiler chickens and determination of amino acid digestibility and metabolizable energy values",** protocol **nº 034/2021**, under the responsibility of **Luiz Fernando Teixeira Albino** - which involves the production, maintenance and/or use of animals belonging to the phylum chordata, subphylum vertebrata (except man), for scientific research purposes (or education) - is in accordance with the law nº. 11.794, of October 8, 2008, Decree nº. 6899 of July 15, 2009, and the rules issued by the Brazilian National Council for Animal Experimentation Control (CONCEA), and was approved by the Ethics Commission on the use of farm animals of Universidade Federal de Viçosa (CEUAP-UFV) in its meeting on **Jul. 09th, of 2021**.

Finality: **(x)Research** ( )**Education**
Duration of the Project: from **Aug. 03th of, 2021** to **Mar. 03Th, of 2022**.
Species / strain: **Broiler** ***(Gallus domesticus)*** Nº of animals: **1810**
Weight: **0,04 Kg** Age: **1 day** Sex: **Male** Source: **Incubatorio Rivelli CNPJ/CPF: 478.715.616-49**
Endereço: Rua Leão José, 257 Mateus Leme, MG Responsável : Maria Cecília CRMV: 10595

Luciana Navajas Rennó
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Coordenadora da CEUAP/UFV