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Digestibility, performance and economic efficiency of diets containing phytase and distillers dried grains with solubles for growing pigs

Digestibilidade, desempenho e eficiência econômica de dietas contendo fitase e grãos secos de destilaria com solúveis para suínos em crescimento

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ABSTRACT

This study aimed to evaluate the effects of phytase enzyme and distillers dried grains with solubles (DDGS) on the digestibility, performance and economic viability of growing pigs. Two experiments were conducted with a reference diet (RD) based on corn and soybean meal: RD with 200 g kg^{-1} DDGS (DDGS); RD + 1,000 units of phytase (PHY); and RD + 200 g kg-1 DDGS + 1,000 units of phytase (D+P). In experiment 1, eight castrated male pigs weighing 29.35 ± 5.74 kg were used through the total collection method and replicates in time for digestibility evaluation. In experiment 2, 40 castrated male pigs 47.65 ± 3.99 kg, with five replicates of two animals per experimental unit, were used for performance and economic evaluation. DDGS increased the excretion of nitrogen and energy in feces and urine, impairing the digestibility coefficients and metabolizability of dietary energy. The animals that consumed diets with DDGS

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presented the worst performance, while phytase did not influence the results. Diets with the inclusion of 200 g kg^{-1} DDGS and 1,000 units of phytase did not differ in cost per kilogram compared to the control diet.
Key words: coproducts, DDGS, digestible energy, metabolizable energy, total collection of feces

RESUMO

Este estudo objetivou avaliar os efeitos da enzima fitase e dos grãos secos de destilaria com solúveis (distillers dried grains with solubles - DDGS) sobre digestibilidade, desempenho e viabilidade econômica de suínos em crescimento. Foram realizados dois experimentos, com uma dieta de referência (RD) à base de milho e farelo de soja; RD + 200 g kg^{-1} DDGS (DDGS); RD + 1.000 unidades de fitase (PHY); e RD + 200 g kg^{-1} DDGS + 1.000 unidades de fitase (D + P). No experimento 1, oito suínos machos castrados com peso de 29,35 ± 5,74 kg foram usados através do método de coleta total, com repetição no tempo para avaliação da digestibilidade. No experimento 2, 40 suínos machos castrados 47,65 ± 3,99 kg, com cinco repetições de dois animais por unidade experimental foram usados para avaliação de desempenho e viabilidade econômica. DDGS aumentou a excreção de nitrogênio e energia nas fezes e na urina, prejudicando os coeficientes de digestibilidade e a metabolizabilidade da energia. Os animais que consumiram dietas com DDGS apresentaram pior desempenho enquanto a fitase não afetou os resultados. As dietas com a inclusão de 200 g kg^{-1} DDGS e 1.000 unidades de fitase não diferem no custo por quilograma em relação à dieta de controle.
Palavras-chave: coleta total de fezes, coprodutos, DDGS, energia digestível, energia metabolizável

INTRODUCTION

The distillers dried grains with solubles - DDGS is considered the main ethanol coproduct obtained from grinding of the grains, mixing with water, fermentation with yeasts converting the sugar component into alcohol, distillation where ethanol and other nonvolatile components, known as whole vinasse, are separated in drying tanks (Buenavista et al., 2021), whose supply has been increasing significantly in Brazil and worldwide.

In the production of ethanol from corn, grain starch is fermented into ethanol, while ether extract, acid detergent fiber, neutral detergent fiber, crude protein, mineral matter and energy have increased proportions in DDGS; however, digestibility is slightly less than in corn (Stein and Shurson, 2009). Some studies have shown that these components may influence the animal organism, especially in energy and nitrogen (N) balance (Adeola & Kong, 2014; Wang et al., 2016). Thus, it is necessary to know the availability of nutrients and energy of these coproducts for a more precise formulation (Adeola & Kong, 2014), as they characterize the effects on animal performance and economic viability. Meanwhile, there is very little information about the nutritional value of DDGS produced in Brazil (Corassa et al., 2017, 2021).

The presence of phytic acid in cereal products has limited the use of all nutrients by animals. Changes such as the formation of complexes insoluble in

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the stomach and small intestine involving phosphorus, calcium, amino acids and fats, increased endogenous losses of minerals and amino acids, reduced activity of Na–K-ATPase in the TGI, and inhibition of enzymes such as trypsin and α-amylase were attributed to phytic acid, resulting in reduced nutrient utilization, increased maintenance protein and energy costs and reduced energy availability for production (Dersjant-Li et al.,2015). As an alternative exogenous phytase enzyme, it is commonly used in monogastric feed, improving performance (Dersjant-Li et al., 2018) and digestibility of energy and nitrogen (Dadalt et al., 2015) in growing pigs.

Nonetheless, this study presents the hypothesis that there is an effect of phytase on the fraction of phytic acid of corn and soybean meal diets containing DDGS considering that it has been little investigated (Swiatkiewicz et al., 2016, Woyengo et al. 2016, Coelho et al., 2019) and not conclusive, which can be a strategy to improve the energy and balance the performance of growing pigs.

The objective of this study was to evaluate the effects of DDGS and phytase on digestibility of diets, performance of growing pigs and economic viability.

MATERIAL AND METHODS

Two experiments were conducted with growing pigs. In the first experiment, the method of total collection of feces and urine (Sakomura & Rostagno, 2016) was used with eight barrows of 29.35 ± 5.74 kg, individually housed in metabolic cages as an experimental unit in a randomized block design and four replicates per treatment performed with two rounds. The animals were fed one of four diets: reference diet (RD, Table 1) based on corn and soybean meal (Rostagno et al., 2017); RD with 200 g kg^{-1} distillers dried grains with solubles - DDGS (DDGS), RD with 1,000 units of phytase (PHY); and RD with 200 g kg^{-1} DDGS and 1,000 units of phytase (D+P). DDGS was included in the diets with isometric substitution of the reference diet (Sakomura & Rostagno, 2016), while 6-phytase from *E. coli* was included on top. The experimental period lasted sixteen days divided into two periods, with three days for adaptation and five days for collection of feces and urine each.

Table 1. Proximate and calculated composition of diets for growing pigs with different levels of DDGS and phytase inclusion

	DR (Exp.1)	DDGS (g kg^{-1})/Phytase (FIT) (Exp. 2)			
Ingredients (g kg^{-1})		0/0	0/1000	200/0	200/1000
Corn	616.70	768.27	768.07	674.20	674.00
DDGS [1]	0	0	0	200.00	200.00
Soybean meal	302.6	208.80	208.80	100.00	100.00
Rice bran	30.0	0	0	0	0
Soybean oil	18.90	0	0	0	0
Dicalcium phosphate	17.50	10.92	10.92	9.00	9.00
Calcitic Limestone	5.20	4.23	4.23	6.00	6.00

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Common salt	4.6	3.80	3.80	3.80	3.80
L-Lysine-HCl	1.5	1.82	1.82	5.00	5.00
Mineral/vitamin Premix [2]	3.00	2.00	2.00	2.00	2.00
Phytase	0	0	0.20	0	0.20
DL-Methionine	0	0.17	0.17	0	0
Total	1000	1000	1000	1000	1000
Calculated Nutritional composition					
Metabolizable energy (kcal/kg)	3,230	3,230	3,230	3,300	3,300
Crude protein (g kg^{-1})	189.9	156.7	156.7	160.2	160.2
Calcium (g kg^{-1})	7.2	5.0	5.0	5.0	5.0
Available phosphorus (g kg^{-1})	3.6	2.46	2.46	2.49	2.49
Digestible Lysine (g kg^{-1})	10.0	8.0	8.0	8.0	8.0
Crude fiber (g kg^{-1})	28.9	24.3	24.3	35.0	35.0

[1] Composition per kg: 300.4 g CP; 48.8 g MM; 928.5 g DM; 66.9 g 1 EE 4,780 kcal GE 3,304 kcal DE and 3,277 kcal ME. [2] Composition per kg of diet: copper (0.01 mg kg^{-1}), iron (0.06 mg kg^{-1}), zinc (0.08 mg kg^{1}), manganese (0.03 mg kg^{-1}), selenium (0.00028 mg kg^{-1}), iodine (0.0008 mg kg^{-1}), cobalt (0.0005 mg kg^{-1}), choline (0.1 mg kg^{-1}), vitamin A (5.5 Ul), vitamin D3 (1.2 Ul), vitamin E (0.03 Ul), vitamin K3 (0.0025 mg kg^{-1}), nicotinic acid (0.02 mg kg^{-1}), pantothenic acid (0.012 mg kg^{-1}), folic acid (0.00025 mg kg^{-1}), biotin (0.01 mcg kg^{-1}), vitamin B1 (0.0008 mg kg^{-1}), vitamin B2 (0.0005 mg kg^{-1}), vitamin B6 (0.0016 mg kg^{-1}), vitamin B12 (0.0018 mcg kg^{-1}), ethoxyquin (0.01 mg kg^{-1}), BHT (0.02 mg kg^{-1}), and zinc bacitracin (0.03 mg kg^{-1}).

Animals were fed ad libitum twice a day in the adaptation period, and the feed intake was registered. In the collection period, the diets were given so that all animals had consumed the same amount of feed per unit of metabolic weight ($LW^{0.60}$), similar to Corassa et al. (2017).

Feces and urine were collected, weighed, and homogenized, and samples equivalent to 200 g kg^{-1} of the total were taken, stored in plastic bags, identified and stored in a freezer (10°C). Urine was filtered as it was excreted through a filter cloth coupled into the funnel of the urine collecting box and then collected in plastic buckets containing 10 mL of 1:1 HCl.

After the collection period, fecal samples were thawed, weighed, homogenized and dried in a forced ventilation oven (60°C/72 hours) for partial drying. The samples were processed in a knife mill with 1 mm sieves for the following analyses: dry matter (DM) (INCT-CA G-003/1), mineral matter (MM) (INCT-CA M-001/1), ether extract (EE) (INCT-CA G-005/1), nitrogen (N) and crude protein (CP) (INCT-CA N-001/1) (Detmann et al., 2021). The organic matter content (OM) was determined by the difference between the DM content and the MM. The gross energy (GE) values of the samples were determined in an adiabatic calorimeter (PARR 6400).

Based on the consumption and excretion of DM, N and GE, nitrogen balance, digestible and metabolizable N values, digestibility coefficients (DC) of DM and energy and energy metabolizability coefficient were determined, in addition to the digestible (DE) and metabolizable (ME) energy of diets (Sakomura & Rostagno, 2016).

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In experiment 2, forty barrows of 47.65 ± 3.99 kg were distributed in a randomized block design with four treatments, five replicates of two animals per experimental unit and body weight as criteria for blocks over 26 days. The treatments evaluated were the same in experiment 1, with nutritional matrix for DDGS and without for phytase inclusions (Table 1). Daily average feed intake (DFI), daily average weight gain (DWG) and feed conversion (FC) were evaluated from 0 to 14, 15 to 26 and 0 to 26 days.

Using the performance data of experiment 2, the cost per kilogram of weight gain was calculated (Bellaver et al., 1985): Yi = (Qi x Pi)/Gi, where Yi = cost of the feed per kilogram weight gained; Pi = price per kilogram of the feed used; Qi = amount of feed intake and Gi = weight gain. The cost index (CI) and economic efficiency index (EEI) were calculated: EEI = (MCei/CTei) x 100 e IC = (CTei/MCei) x 10 (Barbosa et al., 1992), where MCei = lower cost of feed per kilogram gained among treatments and CTei = cost of treatment i. The corn and soybean meal costs (R$/kg) were based on the historical series of the Instituto Mato-grossense de Economia Agropecuária (IMEA, 2020), and the other ingredients (R$/kg) were based on the local market from the middle northern region of Mato Grosso state in the month of the experiment: DDGS 0.45; soybean meal 1.04; corn 0.27; dicalcium phosphate 2.28; limestone 0.13; salt 0.13; L-lysine 4.75; DL-methionine 22.97; premix 3.40 and phytase 44.00.

Data were tested by analysis of variance using the mixed procedure of the Statistical Analysis System (SAS Institute, Inc., Cary, NC, USA). The mathematical model included the effect of treatments in a 2X2 factorial arrangement, with two levels of inclusion of DDGS (0 and 200 g kg^{-1}) and two levels of phytase (0 and 1000 FTU) and block effect, as follows: Yijk = μ + Di + Fj + D*Fij + Bk + eijk, where Yijk = observed variables; μ = overall mean; Di = effect of levels of inclusion of DDGS (i = 0 or 200 g kg^{-1}); Fj = effect of levels of inclusion of phytase (j = 0 or 1000 FTU); D*Fij = effect of interaction between DDGS and phytase; Bk = block effect; Eijk = random error. The significance level was set at 0.05.

RESULTS AND DISCUSSION

There was no interaction (P> 0.05) between phytase and DDGS, as there was no effect of phytase (P> 0.05) for all variables evaluated (exp. 1 and 2). The addition of phytase did not affect any response of the treatments; the same was observed by Tsai et al. (2020), in which the levels of phytase in diets based on corn and soybean meal for pigs were investigated without an effect on the energy value of the diet and the protein digestibility coefficient. The diversity of chemical characteristics as target substrates among vegetable ingredients and enzymes suggests differences in phytase responses.

The hypothesis of the present study was that the action of the phytase enzyme broke the chelates of phytic acid involving minerals and amino acids in DDGS, corn and soybean meal, releasing energy, which was not confirmed. The use of phytase without considering its nutritional matrix and reduction of diet energy levels may have been determinant in the results because, when formulating with ideal levels, or above, the surplus energy would not be used by the animals. Kerr et al. (2010) suggested

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that if there is an effect of phytase on energy digestibility, it is relatively small in magnitude and highly variable. Thus, an enzyme complex may be required to effectively disintegrate the complex matrices of carbohydrate structures in DDGS (Swiatkiewicz et al., 2016).

The inclusion of DDGS in the diets increased (P <0.05) the dry matter excreted (DM exc.), nitrogen and energy excreted by feces and urine, reducing the apparent DM (DMDC), digestible (EDC) and metabolizable (EMC) coefficients (P <0.05) (exp. 1, Table 2).

The inclusion of DDGS did not influence DM intake, similar to the study of Adeola and Kong (2014), while greater DM exc may have occurred due to the limited capacity of the digestive tract of pigs to digest fiber material by endogenous digestive enzymes, reducing the digestibility of nutrients, as in traditional nutrition studies (Li et al., 2020). However, Corassa et al. (2017), investigating levels up to 600 g kg^{-1} DDGS, registered a linear reduction in DMDC but no effect in DE and ME.

Table 2. Daily balance, digestibility and metabolizability of DM, N and energy of diets containing DDGS and/or phytase provided for growing pigs (exp. 1).

Item	DDGS[1] (g kg^{-1})		PHYTASE (FIT)		Significance[2]			
	0	200	0	1000	DDGS	FIT	D*F	CV(%)[3]
DM cons. (g day^{1})	1186	1183	1193	1176	0.9461	0.7560	0.6059	8.84
DM exc. (g day^{-1})	157	205	182	179	0.0052	0.8486	0.5296	15.44
DMDC (g kg^{-1})	867.3	826.2	846.6	846.8	0.0052	0.9870	0.3800	2.85
N cons. (g day^{1})	34.28	37.09	35.95	35.42	0.1040	0.7430	0.6006	8.94
N exc. feces (g day^{1})	5.15	6.75	5.95	5.96	<0.0001	0.9600	0.0550	8.20
N exc. urine (g day^{1})	6.72	7.98	7.59	7.11	0.0398	0.3913	0.3635	14.80
Nitrogen balance	22.41	22.36	22.42	22.35	0.9799	0.9750	0.6740	17.80
Digestible Nitrogen (g kg^{-1})	848.9	816.4	833.4	831.9	0.1198	0.9363	0.3750	4.67
Metabolizable Nitrogen (g kg^{-1})	652.2	599.2	620.4	631.0	0.1268	0.7472	0.8951	10.32
Energy intake (kcal day^{-1})	4726	4911	4854	4784	0.4034	0.7492	0.6035	8.89
Energy feces excretion (kcal day^{-1})	623	855	743	735	<0.0001	0.8305	0.2785	10.36

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EDC (g kg^{-1})	867.6	825.1	846.5	846.2	0.0063	0.9856	0.3527	3.05
DE (kcal kg^{-1})	3457	3426	3442	3440	0.5740	0.9699	0.3476	3.02
Energy urine excretion (kcal day^{-1})	25.96	28.10	27.11	26.96	0.0272	0.8630	0.6881	6.30
EMC (g kg^{-1})	862.1	819.3	840.8	840.6	0.0064	0.9835	0.3490	3.09
ME (kcal kg^{-1})	3435	3402	3420	3417	0.5530	0.9683	0.3462	3.07

[1]DDGS: Distillers Dried Grains with Solubles. [2]Significance level <0.05. [3]CV: Coefficient of Variation. DM cons (consumed dry matter); DM exc. (excreted dry matter); DMDC (dry matter digestibility coefficient); N cons. (consumed nitrogen); N exc. feces (nitrogen excreted in feces); N exc. urine (nitrogen excreted in urine); NB (nitrogen balance); DN (digestible nitrogen); MN (metabolizable nitrogen); E cons. (consumed energy); E exc. feces (energy excreted in feces); EDC (energy digestibility coefficient); DE (digestible energy); E exc. urine (energy excreted in urine); EMC (energy metabolizability coefficient); ME (metabolizable energy).

An increase in fecal N excretion in diets with DDGS was also recorded by Woyengo et al. (2016), resulting in worse N retention, energy and N digestibility; however, the inclusion of phytase with DDGS equaled the nitrogen balance and digestibility coefficients to the control diet. Differences in the phytase effect may be related to the lower phosphorus levels used in that study.

Due to increased nitrogen and energy excretion, pigs have diets with worse digestibility coefficients of dry matter, crude protein and digestible energy, as observed by Wang et al. (2016). The smallest EDC and EMC in diets with DDGS may be to a considerable fraction of energy lost during the fermentation process with the production of methane and heat, reducing the efficiency of energy use (Kerr et al., 2010). Adeola & Kong (2014), when testing the digestibility of diets with DDGS, confirmed that energy intake was not affected, but the DE and ME were higher in the diet without DDGS due to high fiber content.

The higher fecal and urinary excretion of N in pigs fed DDGS (exp. 1) can be explained by the high protein and fiber content of the coproduct. The protein imbalance in the diets with DDGS in the method to evaluate digestibility led to excess nitrogen that the animal organism could not use in totality, resulting in the excretion of N in the feces and urine.

From this perspective, Abelilla & Stein (2019) showed that apparent ileal and total digestibility of energy and protein were lower in diets containing DDGS since it increased the dietary fiber concentration, thereby reducing digestibility and increasing endogenous nutrient loss. However, it was observed that there was no effect of DDGS on duodenal digestibility in pigs, indicating that fermentation of dietary fiber occurs mainly in the hindgut.

The DDGS inclusion worsened (P <0.05) the DFI and DWG during 0-14 and 0-26 days and the body weight of pigs (P <0.05) at 26 days in experiment 2 (exp. 2, Table 3)

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Table 3. Daily feed intake (DFI), daily weight gain (DWG), feed conversion (FC), weight gain (WG) and weight of growing pigs fed DDGS and phytase (exp. 2).

	DDGS[1] ($g\ kg^{-1}$)		Phytase (FIT)		Significance[2]			
Item	0	200	0	1000	DDGS	FIT	D*F	CV(%)[3]
Period 1 (0-14 days)								
DFI ($g\ day^{-1}$)	2700	2400	2480	2620	0.0045	0.1109	0.6248	7.34
DWG ($g\ day^{-1}$)	1012	855	922	945	0.0225	0.7029	0.5579	14.31
FC	2.69	2.84	2.70	2.83	0.4003	0.5007	0.6073	14.56
Period 2 (15-26 days)								
DFI ($g\ day^{-1}$)	2970	2820	2850	2940	0.1302	0.4099	0.2280	7.42
DWG (g g day^{-1})	970	861	922	909	0.0617	0.8002	0.6019	12.83
FC	3.09	3.31	3.11	3.29	0.2742	0.3950	0.9446	13.79
Total Period								
DFI ($g\ day^{-1}$)	2820	2590	2650	2770	0.0156	0.1759	0.3506	6.72
DWG ($g\ day^{-1}$)	992	858	922	928	0.0025	0.8607	0.3771	8.52
FC	2.86	3.02	2.88	2.99	0.1592	0.3269	0.8218	8.26
Animal weight gain								
WG 1	14.17	11.98	12.91	13.24	0.0225	0.7036	0.5566	14.30
WG 2	11.64	10.34	11.07	10.91	0.0619	0.8005	0.6030	12.84
WG Total	25.81	22.32	23.99	24.15	0.0025	0.8628	0.3757	8.52
Body weight of animals during the periods								
Day 0	48.06	47.93	47.94	48.05	0.7568	0.8153	0.7466	2.03
Day 14	62.24	59.91	60.86	61.29	0.0396	0.6768	0.7267	3.69
Day 26	73.88	70.25	71.93	72.20	0.0026	0.7860	0.4811	2.98

[1]DDGS: Distillers Dried Grains with Solubles. [2]Significance level <0.05. [3]CV: Coefficient of Variation.

The difference in DFI and DWG was not sufficient to change FC. Gastric distension due to digesta swelling in the stomach in pigs fed a high-fiber diet reduces feed intake and influences the rate of passage (Ratanpaul et al., 2019) and would occur in the animals of the present study.

In contrast to the results of the present study, Woyengo et al. (2016) evaluated the effect of 100 $g\ kg^{-1}$ DDGS with 600 FTU kg^{-1} phytase and did not observe effects on the performance of growing pigs. Other studies showing that acceptable performance is found up to 300 $g\ kg^{-1}$ DDGS can be included for growing and finishing periods without reducing FC (Buenavista et al., 2021). Studying 65-85 kg pigs, Corassa et al. (2021) showed that inclusion up to 200 g kg^{-1} DDGS did not affect performance and carcass, suggesting that heavier pigs better support diets with DDGS when compared to the results of the present study. The reduction of performance based on the fiber content present in the DDGS is, according to Burrough et al. (2015), due to increases in the insoluble fiber content, with the potential to affect the bacterial population in the colon.

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The costs of each kilogram of feed were RD R$ 0.4724 kg^{-1} feed; RD + PHY R$ 0.4811 kg^{-1} feed; DDGS R$ 0.4305 kg^{-1} feed; and DDGS + PHY R$ 0.4393 kg^{-1} feed (exp. 2). The lowest costs per kilogram feed produced were obtained with the diets containing DDGS. DDGS and phytase in the diet for growing pigs did not affect (P> 0.05) the economic variables (exp. 2, Table 4).

The economic results showed that although the inclusion of DDGS negatively altered the performance, there was no economic damage. It works as a kind of compensation, since the reduction in weight gain is mitigated by the lower cost of the coproduct. Likewise, De Jong et al. (2012) concluded that the CWG of pigs fed DDGS was similar to that of the control group, while the economic analysis of Corassa et al. (2021) resulted in 184.1 g kg^{-1} DDGS as the optimal inclusion.

Globally, DDGS attracts pig farms due to its relatively low price, undervalued according Buenavista et al. (2021) considering the actual economic value in animal diets due to its nutritional content. Although the economic viability of DDGS is related to the price of the coproduct and to the price of corn, soybean meal and other ingredients, this study shows that the use of DDGS reduces feed price, but the local price variation may determine the feasibility of its use.

Table 4. The average cost per weight gain (CWG), cost index (CI) and economic efficiency index (EEI) of pigs fed DDGS and phytase in the growing phase (exp. 2).

Item	DDGS[1] ($g\ kg^{-1}$)		Phytase (FIT)		Significance[2]			
	0	200	0	1000	DDGS	FIT	D*F	CV(%)[3]
Period 1 (0-14 days)								
CWG (R$)	1.28	1.24	1.22	1.30	0.5866	0.3212	0.6074	13.79
EEI (%)	69.94	73.38	73.41	69.91	0.4823	0.4759	0.7724	14.95
CI (%)	144.48	139.61	137.57	146.52	0.5865	0.3221	0.6079	13.79
Period 2 (15-26 days)								
CWG (R$)	1.47	1.44	1.40	1.51	0.7180	0.2070	0.9613	12.44
EEI (%)	81.47	83.59	85.66	79.40	0.6483	0.1884	0.9622	12.34
CI (%)	124.10	121.59	118.35	127.35	0.7179	0.2069	0.9615	12.45
Total Period								
CWG (R$)	1.36	1.31	1.30	1.38	0.3409	0.1436	0.8568	8.29
EEI (%)	82.36	85.31	86.32	81.35	0.3592	0.1318	0.8176	8.34
CI (%)	122.26	117.90	116.67	123.50	0.3423	0.1445	0.8545	8.29

[1]DDGS: Distillers Dried Grains with Solubles. [2]Significance level <0.05. [3]CV: Coefficient of Variation.

CONCLUSIONS

The inclusion of 200 g kg^{-1} DDGS in the diet for growing pigs reduces the dry matter and energy digestibility coefficients of the diets, the daily feed intake and the daily weight gain of the animals without worsening the economic viability. The use of phytase with diets containing DDGS does not alter diet

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digestibility, performance or economic viability.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

All practices involving the use of the animals were in accordance with the ethical principles in animal experimentation approved by the Ethics Committee in the Use of Animals of the UFMT (23108.700673/14-4).

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