Economic evaluation of the use of distillers dried grains with solubles in swine feeding

Avaliação econômica do uso de grãos secos de destilaria com solúveis na alimentação de suínos

Evaluación económica del uso de granos secos de destilería con solubles en la alimentación porcina

Received: 05/14/2021 | Reviewed: 05/23/2021 | Accept: 05/27/2021 | Published: 06/11/2021

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Abstract

This study proposes to undertake an economic assessment of the inclusion of different levels of distillers dried grains with solubles (DDGS) in diets for pigs in different production stages and categories (growing and finishing), namely: barrows fed diets containing 0 or 20% DDGS; and finishing barrows and sows fed diets containing 0, 10, 20, and 30% DDGS. A sensitivity analysis was performed on the price of corn in three simulated scenarios with different revenue systems: an optimistic scenario (lowest price); a regular scenario (medium price); and a pessimistic scenario (highest price). Inclusion of DDGS in the swine diet can reduce feeding costs and improve the profitability of production, about finishing males and females, the profit per kilogram of weight gain (US$/kg) were better in 10% of DDGS inclusion, 0.23, 0.28 respectively, but for growing and finishing, it was smaller in 20% (0.32 US$/kg) of DDGS inclusion than the 0% control treatment (0.33 US$/KG). The inclusion of DDGS must be carefully planned, since its use may depress animal performance and its inclusion is linked to the costs of the other ingredients that make up the diet.

Keywords: DDGS; Corn; Co-product; Soybean meal.

Resumo

Este estudo se propôs a realizar uma avaliação econômica da inclusão de diferentes níveis de grãos secos de destilaria com solúveis (DDGS) em dietas para suínos em diferentes fases e categorias (crescimento e terminação), compostas por: suínos machos castrados alimentados com dietas contendo 0 ou 20% de DDGS; e machos em terminação e fêmeas alimentados com dietas contendo 0, 10, 20 e 30% DDGS. Foi realizada uma análise de sensibilidade sobre o preço do milho em três cenários simulados com diferentes sistemas de receita: um cenário otimista (preço mais baixo); um cenário regular (preço médio); e um cenário pessimista (preço mais alto). A inclusão de DDGS na dieta dos suínos proporcionou redução nos custos nutricionais e melhorou a rentabilidade da produção, quanto à terminação de machos e fêmeas, o lucro por quilo de ganho de peso (US$/kg) foi melhor em 10% de inclusão de DDGS, 0,23, 0,28 respectivamente, mas para crescimento e terminação, foi menor em 20% (0,32 US$/ kg) de inclusão de DDGS do que o tratamento controle de 0% (0,33 US$/kg). A inclusão do DDGS deve ser cuidadosamente planejada, pois seu uso pode deprimir o desempenho do animal e sua inclusão está atrelada aos custos dos demais ingredientes que compõem a dieta.

Palavras-chave: DDGS; Milho; Coproduto; Farelo de soja.

Resumen
Este estudio propone realizar una evaluación económica de la inclusión de diferentes niveles de granos secos de destilería con solubles (DDGS) en dietas para cerdos en diferentes etapas de producción y categorías (crecimiento y finalización), a saber: machos castrados alimentados con dietas que contienen 0 o 20% de DDGS; y machos cabríos y hembras porcinas alimentadas con dietas que contienen 0, 10, 20 y 30% de DDGS. Se realizó un análisis de sensibilidad sobre el precio del maíz en tres escenarios simulados con diferentes sistemas de ingresos: un escenario optimista (precio más bajo); un escenario regular (precio medio); y un escenario pesimista (precio más alto). La inclusión de DDGS en la dieta de los cerdos puede reducir los costos de alimentación y mejorar la rentabilidad de la producción, en cuanto al acabado de machos y hembras, la ganancia por kilogramo de aumento de peso (US$/kg) fue mejor en el 10% de la inclusión de DDGS, 0.23, 0.28 respectivamente, pero para el cultivo y el acabado, fue menor en el 20% (0,32 US$/kg) de inclusión de DDGS que el tratamiento de control al 0% (0,33 US$/kg). La inclusión de DDGS debe planificarse cuidadosamente, ya que su uso puede deprimir el rendimiento animal y su inclusión está vinculada a los costos de los demás ingredientes que componen la dieta.
Palabras clave: DDGS; Maíz; Coproducto; Harina de soja.

1. Introduction

Brazil is considered a world pioneer in the use of biofuels and 8 renewable energy. About 45% of the energy and 18% of the fuels consumed in the country are 9 from renewable sources, while in the world 86% of what is consumed comes from 10 non-renewable energy sources (ANP, 2015).

The country is the world's largest producer of sugarcane, so distillation from it predominates, both for its high availability and for its energy efficiency. However, according to USDA (2017a), sugar and ethanol plants are allocating less sugar cane to ethanol production. In the 2017 harvest, approximately 52% of the volume of sugarcane as opposed to 53% in 2016/17, due to favorable sugar prices in the international and domestic markets, driven by the global deficit in sugar supply.

Thus, the use of corn to manufacture ethanol has intensified mainly in the low sugar harvest months, allowing industries to produce ethanol in these previously idle periods, in addition to being one of the outlets for the flow of production in the domestic market (Milanez et al., 2012).

Corn-based ethanol production can still be considered an emerging activity in Brazil, as it corresponds to approximately 1.8% of the total production of the biofuel. However, an important factor to be taken into account in the distillation of corn is that this process generates a by-product of high nutritional value called distillers dried grains with solubles (DDGS).

The distillation process of corn-based ethanol is like that of sugar cane. Both are made through fermentation. In the case of corn, it is necessary to break down the large starch molecules before fermenting, until they are transformed into sugar, which requires more technology for production (Marques & Cunha, 2008).

An estimated 366 million tons of DDGS are generated per year in Brazil (USDA, 2017b). The average final production of DDGS deriving from the distillation process accounts for approximately 30% of the cereal used (Stein & Shurson, 2009). This by-product can be applied in the feeding of all animal species at a low cost (Silva et al., 2016), around 8–13 cents per kilogram, in addition to having a high protein content (34%) and a fat content of 10% (Liaw et al., 2019).

However, wide nutritional variations have been observed in DDGS, which are mainly due to the process employed in the generation of the biofuel (Belyea et al., 2004), and these variations definitely influence its commercial value. Furthermore, little research has been done on the economic impact of DDGS in swine feeding. On these bases, the present study proposes to set about an economic evaluation of the use of DDGS partially replacing corn and soybean meal in swine diets.

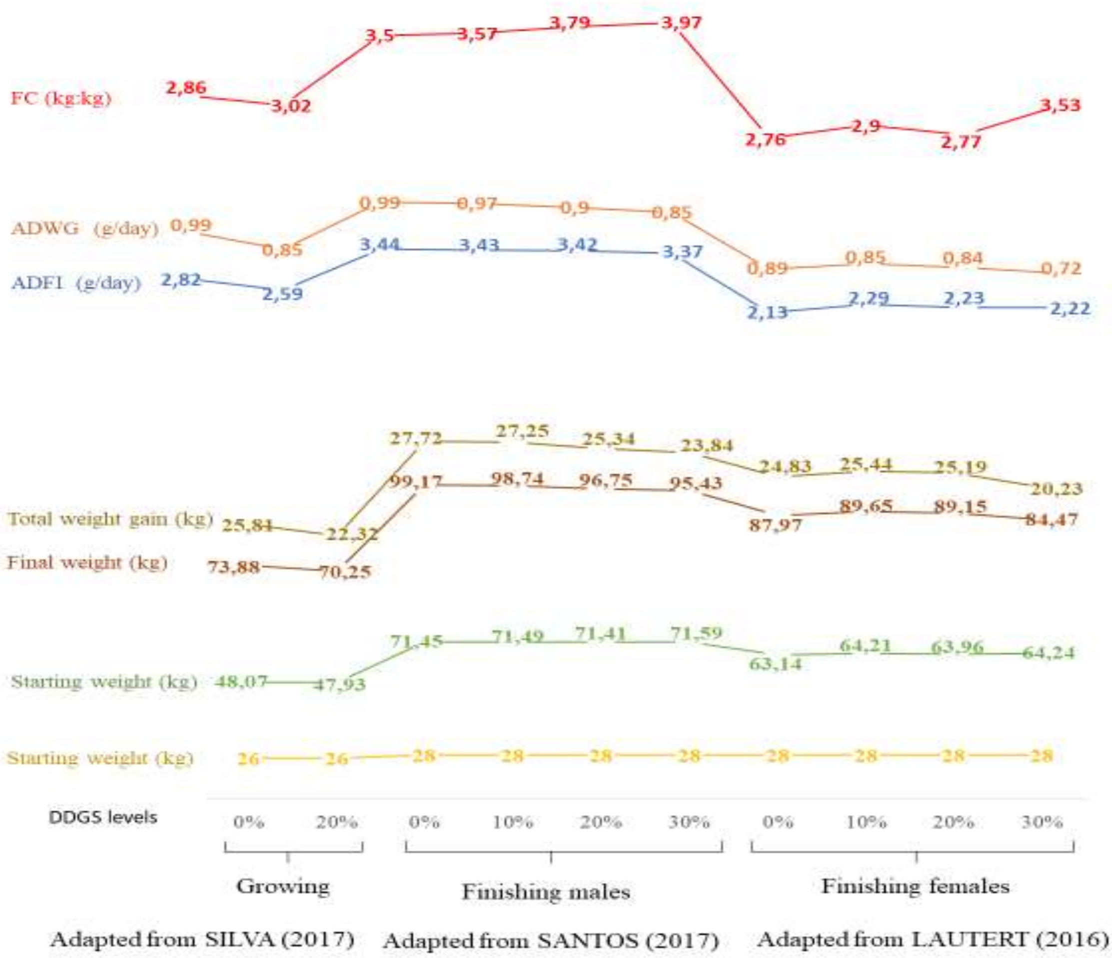
2. Methodology

2.1 Data collect and experimental design

To carry out this study, real animal performance data were collected from three experimental studies (Lautert, 2016; Santos, 2017; Silva, 2017) which were conducted from November 2014 to June 2015 in the municipality of Santa Carmen, a 40 km from the Federal University of Mato Grosso, SINOP campus. The chosen method for this study was quantitative (Pereira et al., 2018).

The characteristics considered were those of animal performance, which was evaluated based on measurements of average daily feed intake (ADFI), average daily weight gain (ADWG) and feed conversion (FC), all these determined weekly in the animals fed corn and soybean meal-based diets formulated to meet the requirements of each category and rearing phase (Figure 1).

Figure1. Performance of different categories of pigs fed levels of inclusion of DDGS in diets.



Source: Adapted from Silva (2017), Santos (2017), Lautert (2016).

It is observed in Figure 1, the means of animal performance characteristics adopted to carry out this work, as well as the different categories of animals used in the three experiments, and the respective percentages of inclusion of DDGS for each category. The final weight was lower as the inclusion of DDGS in the diet increased for growing and finishing males' phase.

For the evaluations, three production scenarios were defined based on the rearing phase and on the sex of the animals and analyzed separately. The first evaluation was defined as 'growing and finishing', in which 20 individuals of the same origin, with an average initial weight of 47.6±3.9 kg, were fed a diet with 20% DDGS and compared with those receiving control diet for 26 days in the growing phase and 28 days in the finishing phase, totaling 54 days.

The second evaluation took place during the finishing phase of the males, using 40 individuals of the same origin, with an average initial weight of 72.6±5.6 kg, for an experimental period of 28 days. The animals were fed diets including 0, 10, 20, or 30% DDGS. Lastly, the third evaluation involved 40 sows in the finishing phase, with an initial weight of 63.89±9.31 kg, which were fed diets containing 0, 10, 20, or 30% DDGS for 28 days.

2.2 Economic equations

Based on the obtained data and the local prices of nutritional feedstock and prices paid for the live pig (males sold at US$ 0.98 and females at US$ 1.13), were calculated the revenues, costs, gross operating profit, gross operating margin, and profit per kilogram of feed conversion, which composed the statement of economic results (SER). Values were converted to U.S. Dollars, adopting the exchange rates given by the Central Bank of Brazil (BC) during the experimental period.

Mathematical-financial calculations were made using the following equations:

$$\text{Gross Revenue (US\$)} = \text{Average Final Weight (kg)} \times \text{N. of animals} \times \text{Average Price of Pig}$$

$$\text{Costs (US\$)} = \text{ADFI} \times \text{ADWG} \times \text{Experimental period} \times \text{N. of animals}$$

$$\text{Gross Operating Profit (US\$)} = \text{Gross Revenue} - \text{Costs}$$

$$\text{Gross Operating Margin (\%)} = (\text{Gross Operating Profit/Revenue}) \times 100$$

$$\text{Profit/Head (US\$)} = \text{Total Profit/N. of Animals}$$

$$\text{KgWG (\%)} = (\text{Total weight gain/ Final weight}) \times 100$$

$$\text{Revenue/kg (US\$/kg)} = (\text{Gross Revenue / N. of animals per lot}) / \text{Final weight}$$

$$\text{Costs/kg (US\$/kg)} = (\text{Nutritional costs / N. of animals per lot}) / \text{Final weight}$$

$$\text{Profit/KgWG (US\$/kg)} = ((\text{Revenue (US\$/kg)} - (\text{Costs (US\$/kg)}) \times (\text{KgWG (\%)})$$

2.3 Sensitivity analysis by MPO methodology

For the sensitivity analysis, were quoted (CEPEA-ESALQ, 2017) the price paid during the corn crop in the period corresponding to the experiments. The MPO methodology was employed (Weston & Brigham, 2000). Three scenarios were simulated, with values obtained from a histogram of distribution of the price paid for corn, namely: a pessimistic scenario (P) with the maximum price (Max) a more likely scenario (M) with a medium price (Med); and an optimistic scenario (O) with the lowest price (Min). These were used for the reasoning of fluctuations both in revenue and cost, independently, and compared with the local value.

3. Results and Discussion

In the diets fed to the growing and finishing animals (Table 1), 20% DDGS inclusion led to a drop of US$ 27.24 (2.44%) in revenues, due to the lower animal performance. As stated by López-Vergé et al. (2017), a reduction in performance directly affects the efficiency of a farm, because animals stays in the facilities for a longer period — which is especially true in the growing and finishing sections — thereby reducing the producer's revenue.

Table 1. Demonstration of Economic Results of pigs fed different levels of inclusion of DDGS in diets.

Growing and finishing	DDGS levels (%)			
	0	10	20	30
Variables				
Revenue (US$)	976.65		952.82	
Costs (US$)				
Growing	121.82		101.97	
Finishing	159.05		153.60	
Total costs of Nutrition (US$)	280.88		255.56	
Gross Operating Profit (US$)	695.77		697.25	
Gross Operating Margin (%)	71.24		73.18	
Profit/Head (US$)	69.58		69.73	
KgWG (%)	34.94		31.77	
Profit/KgWG (US$/kg)	0.33		0.32	
Finishing males				
Variables				
Revenue (US$)	976.65	972.41	952.82	939.82
Nutritional costs (US$)	159.05	151.90	153.60	153.63
Gross Operating Profit (US$)	817.60	820.51	799.22	786.19
Gross Operating Margin (%)	83.71	84.38	83.88	83.65
Profit/Head (US$)	81.76	82.05	79.92	78.62
KgWG (%)	27.95	27.60	26.19	24.98
Profit/KgWG (US$/kg)	0.23	0.23	0.22	0.21
Finishing Females				
Variables				
Revenue (US$)	990.11	1009.02	1003.39	950.72
Nutritional costs (US$)	110.91	118.80	109.31	109.34
Gross Operating Profit (US$)	879.20	890.22	894.09	841.38
Gross Operating Margin (%)	88.80	88.23	89.11	88.50
Profit/Head (US$)	87.92	89.02	89.41	84.14
KgWG (%)	28.23	28.38	28.26	23.95
Profit/KgWG (US$/kg)	0.28	0.28	0.28	0.24

Source: Authors (2020).

In Table 1 it is observed that DDGS inclusion reduced nutritional costs of growing and finishing, however the kilogram of weight gain reduces too, consequently reducing the profit per kilogram and reducing revenues.

By contrast, the lower cost obtained with DDGS inclusion in the diet resulted in a savings of US$ 25.31 (9.01%). Thus, a slightly higher gross operating profit was obtained with DDGS (approximately US$ 1.48 = 0.21%). Consequently, the gross operating margin of the diet improved by 1.94% and the profit per head was also higher with DDGS inclusion. The kilogram of weight gain and profit per kilogram of weight gain were smaller in 20% of DDGS inclusion than the control treatment for the period of growing and finishing.

Those findings corroborate Hilbrands et al. (2013), who evaluated the inclusion of 10 and 20% DDGS in corn and soybean meal-based diets and concluded that the use of the by-product does not compromise animal performance. Rather, it lowers feeding costs in addition to allowing for the withdrawal or inclusion of the ingredient according to fluctuations in feedstock prices during the production period.

Overall, in the finishing of the barrows (Table I), DDGS inclusion provided a reduction in the cost of the diets, producing savings of up to US$ 5.42 (3.40%) at the level of 30%. This observation is in line with the analyses made by Shurson et al. (2003) who stated that DDGS inclusion in diets commonly formulated on the basis of corn and soybean meal will usually reduce their costs. Also, in that study, the authors found that 10% inclusion of the by-product led to savings of US$ 1.40/t of feed (1.28%). However, there was a gradual decline in the revenues obtained with DDGS, which amounted to up to US$ 36.83 (3.77%) with 30% DDGS in the diet composition.

Despite the decreased revenue, the diet with 10% inclusion of the ingredient provided a US$ 2.92 (0.36%) higher gross operating profit than control diet, whereas the other diets were lower by up to US$ 31.41 (3.84%) in this parameter. The gross operating margin of the diets with 10 and 20% inclusion of DDGS were 0.66 and 0.17% higher than that obtained with control diet, respectively, whereas the worst gross operating margin was found in the diet with 30% inclusion, which was 0.06% lower than that of control treatment.

In the evaluation of profit per head, the diet with 10% inclusion of DDGS was also superior; it was US$ 0.29 (0.36%) more profitable than control diet. At levels greater than that, however, profitability dropped by up to US$ 3.14/head (3.84%), obtained at 30% inclusion, when the kilogram of weight gain and the profit per kilogram of weight gain were evaluated, DDGS inclusion generated lower profitability, this shows that although DDGS inclusion in the diets led to savings in production, the decline in animal performance mitigates the efficiency of the system.

Worsened performance in finishing animals fed DDGS has already been reported by some authors. According to Widmer et al., 2008, who observed a decline in performance, it is possible that the quality of the DDGS used in their experiment was lower (lower nutrient digestibility) than expected, along with the fact that the use of the by-product elevates the concentration of dietary insoluble fiber. This fraction causes alterations in the microbiota of the gastrointestinal tract, possibly predisposing the animals to colitis (Burrough et al., 2015). Therefore, the obstacle has been to decrease its result on reducing carcass yield and pork fat quality too (Shurson, 2018).

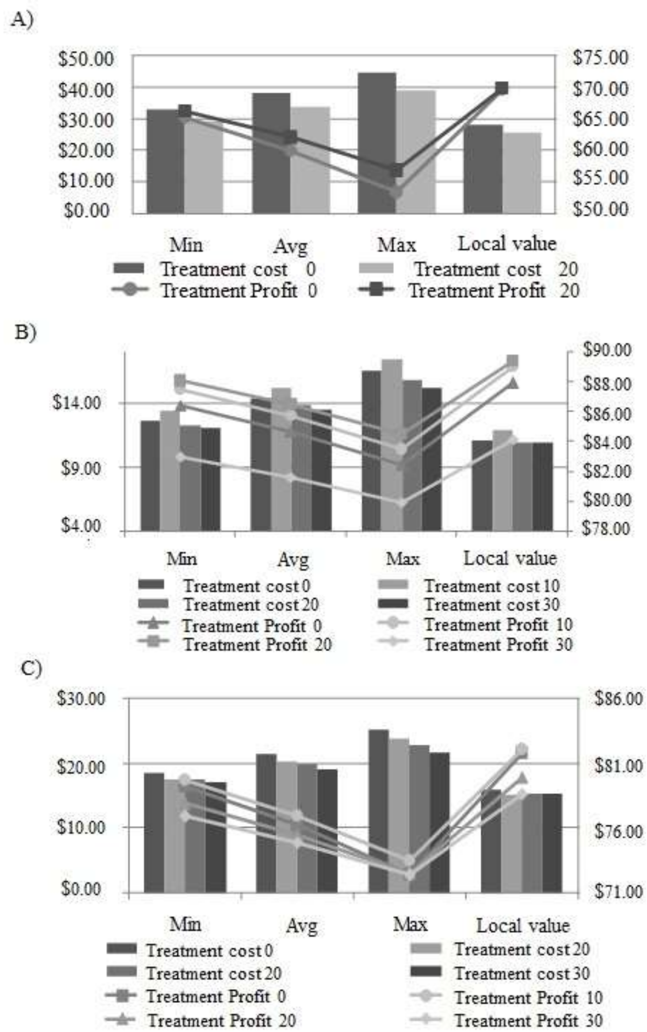
In the finishing of the sows (Table I), DDGS reduced the nutritional costs only at the levels of 20 and 30%, which were US$ 1.61 (7.10%) and US$ 1.57 (1.41%) more economic. The diet with 10% inclusion elevated the cost by US$ 7.88 (7.10%). These results may be explained by Stein (2007), who suggested that the economic viability of DDGS depends on the price paid for its substitutes, e.g. corn and soybean meal. Those researchers recommended that the maximum price paid for DDGS should not exceed around 16% of the price of corn, and that it should be 37% lower than the price of soybean meal.

The greatest revenue was attained at the inclusion level of 10% (US$ 18.91), which was 1.91% higher than that obtained with control treatment, followed by the diet with 20% DDGS (US$ 13.28 = 1.35%). The lowest revenue, in turn, was obtained at 30% inclusion of the ingredient (US$ 39.39), which was 4.03% lower than the revenue provided by control treatment.

For gross operating profit, the diet with the DDGS level of 20% was US$ 14.89 (1.69%) more profitable than control diet, followed by the diet with 10% of the ingredient (US$ 11.02 = 1.25%). The treatment containing 30% DDGS, in turn, had a US$ 37.82 (4.30%) lower gross operating cost than control diet. These results contrast with the findings of De Jong et al. (2012), who evaluated sows fed 30% DDGS in different particle sizes. Those authors reported that although the use of the by-product resulted in worse revenues, because of the decreased animal performance, the reduction of diet costs offset the gross operating profit, generating similar results across the diets.

Gross operating margin decreased with the inclusion of 10 and 30% DDGS, which led to 0.6 and 0.3% lower values, respectively, in comparison with the results obtained with control diet. At 20% inclusion, however, gross operating margin was 0.31% higher. Profit per head was higher at 10 and 20% inclusion of DDGS, which resulted in US$ 1.10 (1.25%) and US$ 1.49 (1.69%) more profit per head when compared with control treatment. The least profitable diet was that which included 30% DDGS, which provided a US$ 3.78 (4.30%) lower profit per head than control diet. In the evaluation of the kilogram of weight gain and the profit per kilogram of weight gain, the diet with 30% inclusion of DDGS had the lowest values compared to the other diets.

Figure 2. Sensitivity analysis of the variation in the price paid for corn: A) Growth and Termination; B) Male Termination; C) Female termination.



Source: Authors.

Figure 2 shows the analysis of scenarios of the price paid for corn in the diets of the growing and finishing animals, the diet with DDGS was more profitable in all scenarios. As the price paid for corn was elevated, the disparity between treatments increased, reaching its maximum point in the scenario with the highest price. Results were only close when the price paid for corn was too low, as in the scenario of the local price, suggesting that at prices lower than US$ 0.10/kg, the substitution is not viable.

In the finishing of the barrows (Figure 2), the disparity between the diets decreased as the price paid for corn was elevated, in the different scenarios. The level of 10% DDGS was the most profitable in all cases. Control diet provided the second highest profitability except for the maximum-price scenario, showing that as the corn prices increase, its profitability decreases in relation to the other treatments.

The profitability of the diet with 20% DDGS ranked third in all scenarios, showing greater discrepancy with the other treatments at the point of maximum value. The diet with 30% inclusion was the least profitable in all scenarios.

To determine the maximum price that can be paid for corn in relation to DDGS, for finishing males, other fluctuations were simulated until an equilibrium point was reached, i.e., until which point DDGS inclusion would provide greater profitability. It was found that the price of corn must be at most around 22.86% lower than that of DDGS.

In the sensitivity analysis of the finishing of sows (Figure 2), the diet with 20% inclusion provided the greatest profitability in all scenarios, followed by the diet with 10%. A lower disparity between those diets was observed in the scenarios with the lower price paid for corn, as in the local-price scenario. Control diet led to less profit than the diets containing 10 and 20% DDGS; it was only superior to the treatment with 30% inclusion, which generated less profit than the other levels in all scenarios.

4. Conclusion

Inclusion of DDGS in the swine diet can reduce feeding costs and improve the profitability of production. However, it must be carefully planned since its use may depress animal performance. For future research it is recommended to test more specific levels of inclusion to determine the maximum percentage of inclusion of DDGS to obtain the best animal performance and ensure the best profitability of the production system.

Acknowledgments

This study was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Financing Code 001, the Federal University of Mato Grosso do Sul and the Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT / MS).

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