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The economic viability of L-arginine supplementation in diets for sows in the lactation phase

Viabilidade econômica da suplementação de L-arginina em dietas para matrizes suínas em lactação

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ABSTRACT

The objective of this study was to evaluate the economic viability of L-arginine supplementation in diets for sows during the lactation phase. A descriptive case study was carried out to identify the economic viability of the supplementation of L-arginine in the lactation ration, in relation to the control diet, on the productive performance of hyper prolific sows and their litters. The study was carried out on a commercial farm located in the state of Minas Gerais. It analyzed feasibility criteria such as the marginal physical product (MPPg) and gross margin (GM) in the scenario of technical and economic efficiency, which were compared to the GM in the control group. Technical efficiency was established at 0.71% of L-arginine in daily feed intake according to previous fieldwork by the authors, while economic efficiency obtained in this study was 0.43% supplementation. The relationship between the L-arginine price and the sale price of the piglets directly determined the economic viability, compared to the control group. Thus, initially considering the price of a piglet as R$ 9.76/kg, the cost of L-arginine should not exceed 6.61 times this value; that is, it is estimated at up to R$ 64.50. Therefore, at the final price of L-arginine of R$ 54.88, a piglet should be sold at a price of R$ 8.30/kg to make the supplementation of L-arginine in the diet of lactation-phase swine economically possible.
Keywords: Functional amino acid, Gross margin, Pigs

RESUMO

O objetivo com o trabalho foi avaliar a viabilidade econômica da suplementação de L-arginina em dietas para matrizes suínas durante a fase de lactação. Um estudo de caso descritivo foi realizado para identificar a viabilidade econômica da suplementação de L-arginina na ração de lactação, em relação à dieta controle, sobre o desempenho produtivo de matrizes suínas hiperprolíficas e suas leitegadas. O estudo foi realizado em uma granja comercial localizada no estado de Minas Gerais. Analisou critérios de viabilidade como o produto físico marginal (MPPg) e margem bruta (GM) no cenário de eficiência técnica e econômica, que foram comparados com o GM no grupo controle. A eficiência técnica foi estabelecida em 0,71% de L-arginina no consumo diário de ração de acordo com trabalho de campo prévio

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realizado pelos autores, enquanto a eficiência econômica obtida neste estudo foi de 0,43% de suplementação. A relação entre o preço da L-arginina e o preço de venda dos leitões determinou diretamente a viabilidade econômica, comparado ao grupo controle. Assim, considerando inicialmente o preço de um leitão como R$ 9,76/kg, o custo da L-arginina não deve exceder 6,61 vezes esse valor; isto é, estima-se em até R$ 64,50. Portanto, ao preço final de L-arginina de R$ 54,88, um leitão deve ser vendido ao preço de R$ 8,30/kg para tornar a suplementação de L-arginina na dieta de matrizes suínas em fase de lactação economicamente viáveis.
Palavras-chave: Aminoácidos funcionais, Margem bruta, Suínos

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INTRODUCTION

In recent years, the production and consumption of pork, both in Brazil and worldwide, has grown significantly, increasing attention to the potential of this protein. This is due to a number of factors, such as: the improvement of production systems, innovative technologies used to increase productivity, management efficiency, and the improvement of animal slaughtering standards.

In this context, current-day sows present a characteristic of hyper prolificity, which in turn demands greater milk production for the subsequent development of piglets during the lactation phase. Sow's milk is deficient in some amino acids such as arginine and may compromise piglet development (Wu; Knabe; Kim, 2004). Therefore, the nutritional adjustment of the diets for these sows is very important; the use of industrial amino acids, among them arginine, can be adopted on commercial farms with the objective of increasing productivity.

Arginine is considered a conditionally essential amino acid for piglets because, according to Li et al. (2007), lactating sows and neonatal piglets have deficits in endogenous arginine synthesis, which may limit their performance or compromise their immune system. Arginine is a precursor for the synthesis of several compounds that are important for metabolism, such as urea, citrulline, creatine, polyamines, ornithine, proline, agmatine, and nitric oxide (Wu et al., 1997; Wu & Morris, 1998). Of these, nitric oxide is responsible for the formation and branching of blood vessels (Matsunaga et al., 2002), there by increasing the nutrient supply to the mammary gland of the sows. In addition, arginine stimulates the secretion of prolactin and growth hormone, which are necessary for breast development (Reyes; Karl; Klahr, 1994). Supplementation with 0.71% L-arginine improves piglets' weaning weight, considering 21 days of lactation (Moreira et al., 2018).

The economic viability resulting from nutritional adjustments with amino acids in the lactation phase is an essential parameter to be evaluated when aiming for greater accuracy in nutrition and a reduction of formulation costs, especially when using L-arginine. However, the work involving the study of these relationships is still scarce, resulting in an ephemeral state of the art. The objective of this study was to analyze the economic viability of L-arginine supplementation in diets for pluriparous sows and their respective litters during the lactation phase.

MATERIALS AND METHODS

A descriptive case study was carried out to identify the economic viability of L-arginine supplementation in the sows' diet during the lactation phase in terms of the productive performance of pluriparous sows and their respective litters; this was performed on a commercial farm located in the municipality of Oliveira, in the state of Minas Gerais, Brazil (latitude: 20°50'50.7444 "S, longitude: 44°48'51.7428" W, and 973 m above sea level). According to the Köppen classification, the climate is characterized as humid subtropical (Cwa). Sows were selected based on their reproductive history, with between 12 and 13 piglets born on the previous farrowing and insemination using the same boars (Moreira et al., 2018).The local bioethics committee approved the

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study of Moreira et al. (2018), named as case number 43/13.

Data was used according to a previous study by Moreira et al. (2018), in which the treatments consisted of a control diet (without supplementation of L-arginine) and three diets obtained by supplementation with 0.5, 1.0, or 1.5% of L-arginine, with 98.5% purity; the best response for the performance variables of the litter with 21 days was estimated to be 0.71% supplementation. In this sense, the present work aimed to compare between the control treatment, the supplementation with 0.71% of L-arginine (technical efficiency) and the supplementation with 0.43% of L-arginine (economic efficiency).

The sale price of a piglet was multiplied by the coefficients 2.80 (lactating phase) and 1.00 (finishing phase), based on the indicator of live swine from CEPEA/ESALQ (finishing phase). The average price considered was the price received by the producer, in R$/kg, during the first four months of 2018. The conversion factor 2.8 was estimated by dividing the average price of the weaned piglet by the average price of the finished piglet (Dorow, 2014).

The price of L-arginine was defined based on the value (US$) and the amount (kg) imported by Brazil that was made available by the Aliceweb system, linked to the Ministry of Development, Industry and Foreign Trade (MDIC). It was converted to R$/kg for the price for the respective month, made available by the Central Bank, also for the first four-month period of 2018. A rate of 20% was applied on the price for the importer's profit margin; this approximate percentage was achieved with product suppliers through personal communications.

Thus, the values adopted were R$ 9.76/kg for a piglet at weaning, R$ 3.49/kg for a finished piglet and R$ 54.88/kg for L-arginine. In this sense, the price of one kilogram of L-arginine was 5.62 times greater than the price of one kilogram of a weaned piglet (Px/Py ratio = 5.62).

In the estimation of technical efficiency, a production function was calculated. It was represented by Equation 1, where y represents the weight of the piglet on the 21st day of lactation for the dependent variable x, which refers to the total supplemented amount of L-arginine in the diet of the sows, decreased from the error margin, during the experiment by Moreira et al. (2018). The production function was represented by the following equation (Equation 1):

$$y = 6{,}287.09 + 917.31x - 642.20x^2$$

The work was conducted according to the Theory of Production applied to the economic analysis of experiments (Noronha, 1984). It was considered a production function with only one variable productive factor (supplementation with L-arginine); the other factors were kept constant. The main interest of this study resides in the marginal physical product (MPPg) that is obtained, realizing the first order derivative of the production function. The MPPg measures the effect of one unitary variation in the use of the input on the production, keeping the other inputs unchanged.

Thus, the supplementation with L-arginine that indicated the technical efficiency of the experiment was estimated when MPPg = 0 (maximum piglet weight) and the economic efficiency was when the MPPg = Px/Py (maximum monetary profit). As the production function (Equation 1) was estimated in terms of the percentage of L-arginine supplementation (0%, 0.5%, 1.0%, 1.5%) as a function of the weight of the piglet on the 21st day of lactation

(grams), the Px/Py ratio was also converted into percentage terms to match the units of measurement. The conversion process was conducted multiplying the Px/Py ratio by 64, which this number represents 1% of the daily feed intake in grams. Thus, in practice, the Px/Py ratio was 359.87.

By replacing the efficient amounts of L-arginine in the production function described in Equation 1, it was possible to obtain the maximum amount produced and the economically optimal amount, respectively.

Then, the gross margins (GM) were estimated in the scenarios of technical efficiency, economic efficiency, and in the control group, through Equation 2, as described below:

$$GM = (Py \times y) - (Px - x) - k$$

In which Py and Px are the prices of the product and the variable factor, respectively; y and x are the quantity produced and the quantity of the variable factor, respectively. Finally, k is a constant that represents the other costs common to all scenarios and therefore was considered to be zero, as recommended by Oliveira et al. (2016).

GM can be analyzed as the total revenue obtained with the commercialization of the piglet, excluding the cost of L-arginine (variable factor). Thus, it indicates the direct impact of the input price variation on the economic result (Oliveira et al., 2016).

In order to verify the equivalence of L-arginine supplementation in relation to the control group, the relationship between the price of L-arginine and the price of a piglet that corresponded to the GM of economic efficiency was estimated with that of the control group, which resulted in Equation 3:

$$GM_{eco} = -4.25725^{-13} - 0.0406p_{arginine} + 6.5515p_{piglet}$$

The achievement of the gross margin equation is the result of the simulation of 1775 economically-efficient GM scenarios (GM_{eco}), based on a combination of the possible price variations of L-arginine ($p_{arginine}$) and piglets (p_{piglet}). In other words, a regression of GM_{eco} was estimated on the basis of all possible combinations of prices per kilogram of L-arginine and kilogram of piglet, within a range of prices; the range for L-arginine was from R$ 31.00 to 66.00 (71 scenarios) and that for a piglet was from R$ 3.00 to 15.00 (25 scenarios), both each varying by R$ 0.50. By replacing the GM of economic efficiency by the GM of the control group in Equation 3, given the initial price of one kilogram of piglet, the price of one kilogram of L-arginine was found to equal the two margins and, consequently, the relationship between the two prices equals the two margins.

Performance results of piglets from the experiment by Moreira et al. (2018) used for economic analysis with L-arginine supplementation for lactating sows are presented in Table 1.

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Table 1. Live weight and average daily gain of piglets from lactating sows fed a diet with L-arginine supplementation

Variable	L-arginine supplementation (%)				SEM
	0.0	0.5	1.0	1.5	
Sows (n)	16	15	16	14	
Daily feed intake (g)	6,415	6,398	6,409	6,597	0.714
Piglets/sow on 2nd day	13.12	12.87	12.94	13.14	0.88
Piglets/sow on 21st day	12.75	12.53	12.81	12.71	1.13
Weight on 2nd day (kg)	1.540	1.600	1.560	1.560	0.170
Weight on 13th day (g)	3.988	4.137	4.094	3.858	0.382
Weight on 21st day (g)	6.287	6.585	6.562	6.218	0.522
ADG from 2–13 days (g)	222.3	232.4	228.2	209.6	27.3
ADG from 2–21 days (g)	249.7	263.4	262	245.6	24.8

ADG: Average daily gain

RESULTS AND DISCUSSION

The analysis of the economic viability of L-arginine supplementation initially requires that MPPg be identified. MPPg showed a decreasing trend as a function of L-arginine supplementation, as expected. The production function showed a maximum total weight when the MPPg equaled zero, corroborating the results of Moreira et al. (2018), in which they compared the aforementioned levels and piglet weight gain, and identified 0.71% as the optimal level (technical efficiency) for this nutritional adjustment. From this point, increases in L-arginine in the sows' diet reduced the total weight of the piglets at 21 days of age (Figure 1 and Table 2).

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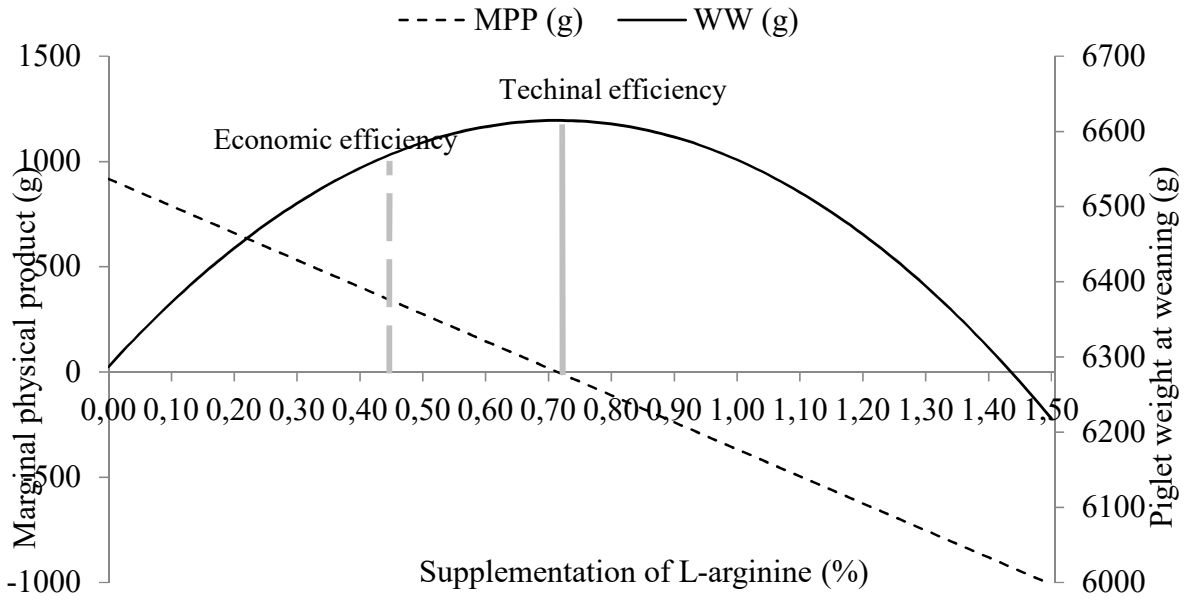

Figure 1. Marginal physical product (MPP) and average piglet weight at weaning (WW), as a function of L-arginine supplementation

Table 2. Live weight and gross margin of piglets from lactating sows fed a diet with L-arginine supplementation

L-arginine supplementation (%)	Weight on 21st day (g)	Gross margin (R$)
0.00	6,287.09	61.36
0.43*	6,564.24	61.65
0.50	6,585.19	61.49
0.71**	6,614.65	60.58
1.00	6,562.20	58.48
1.50	6,218.10	52.09

* Optimum economic efficiency level
** Optimum technical efficiency level

The technical efficiency for the weight of piglets at 21 days generated piglets with a weight of 6,614.66 g (maximum quantity - continuous line in Figure 1). According to Moreira et al. (2018), milk production was not altered, however there was an effect on milk composition, changing protein and fat percentage. Thus, the gross margin of the producer was R$ 60.58 per piglet, given that on the 21st day, supplementation of 0.71% of L-arginine was estimated to be the optimum level, equivalent to approximately 3.81 g/day/piglet per sow, considering a lactation with 12 piglets.

For the economic efficiency of piglet weight on the 21st day, the best inclusion was estimated based on 0.43% of L-arginine, equivalent to approximately 2.32 g/day/piglet per sow, considering a lactation with 12 piglets. This level of efficiency generated piglets with a

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weight of 6,564.24 g (economically optimal amount - dashed line in Figure 1); the result presented a gross margin of R$ 61.65 per piglet.

The comparison of the technical and economic efficiency resulted in a greater gain for the producer of R$ 1.07 per piglet. When extrapolated to an industrial scale of production, this could represent a considerable gross revenue per year. According to the Brazilian Association of Swine Producers (ABCS, 2016), the average size of farms in the southeast region of Brazil is 785 sows and in the south region is 456 sows. Thus, taking into account 2.5 farrowings/year per sow and 12 piglets weaned per farrowing, an additional income of R$ 32.10/sow per year could be obtained.

At weaning, the control group had a weight of 6,287.09 g, which represented a margin of R$ 61.36 per piglet. This result indicated that economically-optimal supplementation with L-arginine may increase the producer's income by R$ 0.29 in relation to non-supplemention, which, taking into consideration 2.5 farrowings/year per sow and 12 piglets weaned per farrowing, would lead to an additional income of R$ 8.70/sow per year.

The equivalence analysis described in Equation 3 indicates an equivalence between the GM of economic efficiency (0.43% of L-arginine) and the control group. Considering a piglet in the value of R$ 9.76, the price of L-arginine, which matched the sales margins, was R$ 64.50/kg. Thus, the gross margin in economic efficiency was also R$ 61.36/kg. Applying the Px/Py ratio, a result of 6.61 was identified. Thus, the price of L-arginine could be up to 6.61 times greater than the price of a piglet, in order for supplementation to be economically viable.

Due to the seasonality of the market, the price of L-arginine may change, and may increase or decrease depending on several factors, such as the dollar price. For the supplementation of L-arginine (0.43%) to become economically viable, the producer needs to obtain a price for the sale of the piglet, which, in the case of this experiment, would be estimated at R$ 8.30/kg considering economic viability, maintaining a Px/Py ratio of 6.61 and GM of R$ 52.18/kg.

Economic viability derived from the equivalence analysis is possible since piglet weight gain with L-arginine supplementation to the diet of pluriparous sows can trigger cumulative gains in profitability received by producers throughout the pig production chain (nursery to slaughter) when the economic efficiency equals the control group, in which there was no supplementation of L-arginine. According to Pinheiro & Dallanora (2014), for each kg added at weaning, there is an additional gain of 4.2 kg at slaughter. Thus, it was possible to estimate the margins of technical and economic efficiency, and those of the control group in the finishing phase.

The piglet weight difference for the optimum level of L-arginine for economic efficiency (0.43%) and in the control group (0%) was 277.15 g at weaning, while during the finishing phase, it was estimated to be 1.16 kg. Thus, the economic efficiency of L-arginine supplementation provided an additional margin of R$ 4.06 per finished piglet, relative to the control animals. Arginine supplementation may improve blood flow and nutrient supply to the mammary gland for milk protein synthesis due to increased nitric oxide synthesis in blood vessel endothelial cells (Wu; Meininger, 2002), thereby

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increasing the weight of piglets at weaning.

The difference between the weight of the piglets in the technical efficiency (0.71%) and the economic efficiency was 50.41 g, or 211.74 g in the finishing phase, which represented a GM gain of approximately R$ 0.72 per live pig sold by the producer. This reduces the difference between the technical and economic efficiency margins from R$ 1.07 per piglet at weaning to R$ 0.35 per piglet during the finishing stage. Finally, even at finishing, the economic efficiency scenario is the most viable for the producer.

It should be noted that the two projections of the above-mentioned finishing phase disregard the costs of L-arginine in the sow feed, since they were already computed in the lactation phase. On an industrial scale, these margin gains per piglet are even more relevant. This gain, and consequently the profitability, tends to multiply until the finishing phase, leading to the economic viability of the experiment.

The logic of the economic viability of L-arginine supplementation during the lactation phase demands the need of an equivalence for GM and economic efficiency; if nutritional adjustment leads to optimal piglet weight, economic efficiency, and in subsequent phases of production, additional weight gain, does not require L-arginine supplementation.

Economic efficiency (greater profitability for the producer) was obtained with the supplementation of 0.43% L-arginine in the diet of lactating sows. Supplementation with L-arginine can be considered economically viable when the price of one kilogram of L-arginine is up to 6.61 times higher than the price of one kilogram of pig.

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