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Effects of maternal L-glutamine supplementation during late gestation on litter performance

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Abstract

To evaluate the effects of glutamine (Gln) supplementation on sow performance during late gestation and lactation and their offspring, eighty pregnant, multiparous sows of a commercial hybrid line were used in a completely randomized, 2 × 2 experimental design at the end of gestation and lactation, respectively. Females were subjected to a control diet or a Gln-supplemented diet (1% of L-glutamine) from 85 d of gestation until farrowing. During lactation, the dietary treatment groups were CON_C: without Gln supplementation; CON_G: Gln only during lactation; GLN_C: Gln only during gestation; GLN_ GLN: Gln during gestation and lactation. At 105 d of gestation, there was no statistical difference regarding the body weight of the sows, however, sows fed the Gln-supplemented diet had greater backfat thickness at P1 and loin depth at P2 than control sows. Placental weight and efficiency showed no effect between treatments. Litters born from Gln-supplemented sows tended to be heavier at birth compared to control litters, reducing the probability of piglets weighing less than 1.5 kg. In addition, litters from supplemented sows had a lower standard deviation of BW at birth. There were no effects of dietary treatments on the performance of sows and offspring during the lactation period. Maternal Gln supplementation during late gestation improved piglet weight and litter uniformity at birth without affecting sow body composition after farrowing.

Keywords: body composition, functional amino acids, lactation, litter characteristics, sow nutrition
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Introduction

Sow productivity has continuously improved over the past decades as a direct consequence of intensive genetic selection, resulting in highly prolific sows (Rutherford *et al*., 2013; Tokach *et al*., 2019). The introduction of these modern lines in commercial herds has led to substantially improved litter size and, consequently, the number of pigs produced per sow per year. Although these improvements have positively influenced the swine industry, the selection for total number born has also resulted in higher incidences of low-birth-weight piglets, increased within-litter weight variability, and increased pre-weaning mortality (Foxcroft *et al*., 2006; Quesnel *et al*., 2008; Amdi *et al*., 2013). In this context, maternal nutrition has been identified as a key factor in the reproductive performance of the sow and the growth and health of its offspring (Douglas, 2013; Krueger *et al*., 2014).

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Inadequate maternal nutrition can result in an insufficient supply of nutrients to meet foetal demand, especially in late gestation and lactation where nutritional requirements increase and voluntary feed intake is often insufficient to satisfy nutrient needs (Wu *et al*., 2006; Kim *et al*., 2013). During these critical periods, the study of functional nutrients has attracted attention as an attempt to better meet sow nutritional requirements and consequently improve reproductive and growth functions in both sows and offspring (Ji *et al*., 2017; Wu *et al*., 2017; Pereira *et al*., 2020). In this regard, glutamine (Gln) is found in abundance in foetal tissue proteins and milk, suggesting an important role in foetal development and piglet growth and health (Wu *et al*., 2011; Yang *et al*., 2018; Quisirumbay-Gaibor, 2020). Because of this, it is known that large amounts of glutamine (Gln) are mobilized from the maternal body stores to the foetus and mammary gland during the gestation and lactation periods, respectively (Manso Filho *et al*., 2008; Wu *et al*., 2017).

Glutamine is classified as a non-essential amino acid (AA) but is important as an energy supplier and precursor for protein synthesis. In addition, Gln has been recognized as a metabolic regulator to increase protein synthesis and reduce catabolism in conditions of high protein degradation (Watford, 2015). Other functional activities of this AA are related to gene expression, cell proliferation, and immune function (Blachier *et al*., 2009; Zhong *et al*., 2012; Kim *et al*., 2013; Vázquez-Gómez *et al*., 2021). Under specific conditions, endogenous Gln production becomes insufficient to satisfy demand (Manso *et al*., 2012; Yang *et al*., 2018). Given this, Gln supplementation in practical diet formulations for sows and its effects on reproductive performance and offspring growth need to be explored and adjusted. Therefore, the objective of this study was to evaluate the effects of diets supplemented with 1% L-glutamine during late gestation and lactation on the performance of lactating sows and offspring under commercial conditions.

Material and Methods

This study was conducted in a manner that avoided unnecessary discomfort to the animals by use of proper management and laboratory techniques. In this regard, the experimental procedures were approved by the Ethics Committee on Animal Use of the Federal University of Lavras (protocol number 62/16), according to the ethical principles adopted by the Brazilian Council for the Control of Animal Experimentation.

This experiment was carried out in a commercial farm located in Lavras, Minas Gerais, Brazil. The herd consisted of approximately 5,000 sows in a farrow-to-finish system with weekly breeding and farrowing groups and a lactation period of 21 ± 3 d. A total of 80 pregnant, multiparous sows from a commercial hybrid line, DB 90 (DanBred, Minas Gerais, Brazil), with a history of high prolificacy (16.5 ± 2.35 total born piglets per litter) were used in the current study. Females were inseminated twice with semen from the same group of males and housed individually in stalls throughout their pregnancy. On day 108 of gestation, females were transferred from gestation stalls to farrowing crates where farrowing was supervised, and standard farm birth care protocols were followed. The internal environment of the facilities was monitored using a data logger (Instrutherm, HT-500, São Paulo, Brazil). The sensors were installed one meter above the sows to collect temperature and humidity data every 10 min throughout the study period.

From days 0 to 84 of gestation, females were fed a common diet based on corn and soybean meal (Table 1) according to the farm's feed management (i.e., 1.8 kg divided into two meals per day). At day 85 of gestation, the 80 sows were assigned to one of two dietary treatments based on parity and body weight (BW) in a completely randomized experimental design. Dietary treatments included a group fed the common gestation diet (CON) and a group provided the common diet supplemented with 1% L-glutamine from 85 d of gestation until farrowing (GLN) (Table 1). During lactation, sows and litters were subdivided into one of four Gln nutritional programs in a 2 × 2 experimental design: CON_C: sows fed CON diet during gestation and a control diet during lactation; CON_G: sows fed CON diet during gestation and L-glutamine-supplemented diet during lactation; GLN_C: sows fed Gln-supplemented diet during gestation and CON diet during lactation; GLN_GLN: sows fed Glu-supplemented diet during gestation and lactation (Table 1). The experimental unit consisted of a sow and its respective litter with 40 replicates per treatment during gestation and 20 replicates per treatment during lactation.

Daily feed allotments were based on the farm's feed management: from day 85 until farrowing, sows received 2.4 kg per day (24 g of L-glutamine for the supplemented group). During lactation, sows received a maximum of 7.5 kg per day (75 g of L-glutamine for the supplemented group). L-glutamine was added to the experimental diets as a top dressing to the morning feed, which means that the amino acid was added directly to the feeders along with the feed. L-glutamine (99.5% pure) was obtained from the Division of Animal Nutrition of Ajinomoto do Brasil Food Industry and Commerce Ltd. (Limeira, São Paulo, Brazil). The sows had free access to drinking water throughout the experimental period.

On day 105 of gestation, day 2 of lactation, and weaning, sows were weighed and backfat and loin depth were measured using ultrasonography at positions P1 and P2 (ALOKA ultrasound, model SSD-500 with a 3.5 MHz linear transducer model, UST 5011). At farrowing, total piglets born, the number of live-born and stillborn for each litter, and their respective weights at birth, were recorded. After the end of each farrowing, the total weight of the placenta was also recorded (placental weight was divided by litter weight to calculate the placental efficiency). The standard deviation of litter birth weight and total live birth piglets was calculated as an indicator of litter uniformity.

Table 1 Experimental diets offered during gestation and lactation (as-fed basis)

Ingredient, g/kg	Gestation	Lactation
Corn, grain	761.7	550.6
Soybean meal, 45% CP	200.5	318.7
Soybean oil	-	42.5
Common salt	5.0	5.0
Sucrose/sugar	-	40.0
L-Lys HCl, 78.8%	-	1.5
L-Threonine, 99%	-	0.7
DL-Methionine, 99%	0.5	0.8
Dicalcium phosphate	15.5	15.5
Limestone calcite	7.4	10.6
Sodium bicarbonate	-	3.0
Choline chloride, 60%	1.0	0.7
Citric acid	-	2.0
Vitamin Premix[1]	0.4	0.4
Trace Mineral Premix[2]	1.0	1.0
Nutritional supplement[3]	4.1	4.1
Kaolin	3.0	3.0
Nutritional composition		
Energy density, kcal ME/kg	3,176.30	3,345.90
Crude protein (CP, g/kg)	150.7	187.5
SID Lys, (g/kg)	6.5	10.3
SID Met, (g/kg)	2.7	3.3
SID Met + Cys, (g/kg)	5.0	6.1
SID Thr, (g/kg)	5.1	7.1
SID Arg, (g/kg)	9.0	12.0
Sodium, (g/kg)	2.2	2.2
Total calcium, (g/kg)	7.3	8.8
STTD phosphorus, (g/kg)	3.8	3.9

[1]Minimum provided per kilogram of product: vitamin A 225,000 IU, vitamin D3 37,500 IU, vitamin E 1,500 mg, vitamin K 75 mg, vitamin B12 625 mg, niacin 1,000 mg, pantothenic acid 500 mg, folic acid 65 mg, biotin 6.75 mg, choline 8,400 mg, pyridoxine 100 mg, riboflavin 150 mg, thiamine 32.5 mg
[2]Minimum provided per kg of product: copper 450 mg, iron 2,750 mg, phosphorus 85 mg, fluorine 850 mg, iodine 17.5 mg, manganese 1,250 mg, selenium 7.5 mg, sodium 49 mg, zinc 2,750 mg, chromium 5 mg, zinc bacitracin 1,000 mg
[3]Nutritional supplement based on enzymes, organic minerals, biotin, mycotoxin inactivator, antibiotic, and antioxidant
ME = metabolizable energy; CP = crude protein; SID = standardized ileal digestibility; STTD = standardized total tract digestibility

Cross-fostering occurred within the first 48 h after farrowing to equalize the number of piglets per sow based on piglet BW. Thus, litter size was standardized to 12–13 piglets per sow within her treatment group. Individual pig weaning weights were recorded at weaning to assess piglet growth performance (average daily gain, ADG) during the suckling period.

Sows milk production was estimated from the equation proposed by Noblet & Etienne (1989):

$$Milk\ yield(g day^{-1}) = \frac{(0.718 \times piglet\ average\ daily\ gain(g) - 4.9) \times number\ of\ piglets}{0.19} \quad (1)$$

The analysis of litter weight uniformity followed the methodology of Moreira *et al*. (2020). Using the mean values and standard deviations of the piglet weights, normal distribution charts were created using Microsoft Office Excel® (2010 version). To guarantee the data were normally distributed, 3.01 standard deviations of the mean were adopted in a 100-point plot, in which the increase in each point was calculated using the following equation:

$$Increase = (\bar{x} + [3.01 \times deviation]) - (\bar{x} - [3.01 \times deviation]) / 100 - 1 \quad (2)$$

where $\bar{x}$ = average piglet birthweight and deviation = standard deviation of the average piglet birthweight.

Subsequently, the probability of each weight in the normal distribution was calculated using the =DIST.NORM.N function within the range of the mean to 3.01 times the standard deviation of the mean, thereby generating the chart in the “insert area chart”/dispersion option for each treatment. By overlapping the normal distribution curves of the weights of piglets from sows supplemented or not with 1.0% L-glutamine, the intersection points (weights) of these curves and thus the probabilities of the areas representing differences between the curves were determined using the =DIST.NORM.N function.

The UNIVARIATE procedure of SAS (v9.3 SAS Inst., Inc., Cary, NC) was used to confirm the homogeneity of variance and to analyse for outliers. For probability values greater than 5% in the Shapiro–Wilks test data distribution was considered normal; otherwise, the PROC RANK procedure of SAS was used to normalize the residuals. The data was analysed as a completely randomized experimental design by using the MIXED procedure of SAS. In the model, sow was used as the experimental unit for measures of sow productivity and piglet performance until weaning, whereas dietary treatment was the main effect. For suckling piglet performance, the lactation period was used as a covariate. Tukey’s adjusted means test was used to detect differences between treatment groups where P <0.05 was considered significant and P <0.1 was referred to as a tendency.

Results and Discussion

There was no substantial effect of dietary Gln supplementation on the body weight of sows at 85 and 105 d of gestation. However, it was observed that the thickness of backfat in P1 was greater (P = 0.039) and loin depth in the P2 position tended to be greater (P = 0.099) in the supplemented group (Table 2).

Table 2 Dietary L-glutamine supplementation during late gestation on sow body condition

Parameters	Control	L-glutamine	SEM	*P*-value
BW at day 85, kg	243.0	239.8	2.912	0.454
BW at day 105, kg	265.6	261.7	2.963	0.381
Backfat thickness at day 105, mm				
P1 position	18.12	19.68	0.525	0.039
P2 position	15.62	15.75	0.402	0.707
Loin depth at day 105, mm				
P1 position	47.88	50.93	1.481	0.133
P2 position	43.86	46.24	0.999	0.099

SEM = standard error of the mean; BW = body weight

In the current study, dietary Gln supplementation during late gestation did not affect BW at day 105 of gestation but increased backfat thickness and loin depth in comparison with the control group. These results are in agreement with the study performed by Zhu *et al*. (2018), who reported that sow BW at day 110 of gestation was not influenced by dietary Gln supplementation from day 85 of gestation until farrowing. Regarding body composition, Manso *et al*. (2012) reported the influence of Gln supplementation in increasing backfat thickness at farrowing. However, this increase seems to be within the range considered acceptable for sows in this category, which indicates that dietary Gln supplementation allows the maintenance of sow body condition, avoiding excessive catabolism.

Late gestation and lactation are characterized by important physiological and metabolic changes that influence the nutritional demands of sows (Kim *et al*., 2013). During these periods, there is an increase in nutritional requirements due to greater foetal growth, development of mammary glands, milk production, and even body growth for young females. As a result, nutrient intake becomes insufficient, and sows use their body reserves to meet the demands (catabolic status). Excessive catabolism can lead to poor performance of sows and piglets during the lactation period and compromise sow reproduction during subsequent cycles (Hoving *et al*., 2012). In this context, Gln supplementation can be justified to minimize these negative effects, since under conditions of high protein degradation, as in late gestation and lactation, Gln can act as a metabolic regulator, increasing its availability and providing an anti-catabolic effect for the animal (Li *et al*., 2009).

There were no differences among dietary treatments for total piglets born, number of live-born and stillborn, average piglet birthweights, and placental efficiency (Table 3). Though the litter birthweight of total piglets born was similar across dietary treatments, the litter birthweight of live-born piglets tended to be greater (P = 0.08) in the Gln group compared to the control group. Furthermore, dietary Gln supplementation reduced (P <0.05) the within-litter standard deviation of piglet birthweight by 47 g.

Table 3 Dietary L-glutamine supplementation during late gestation on litter characteristics and uniformity

Parameters	Control	L-glutamine	SEM	*P*-value
Total piglets born, n	17.26	16.97	0.460	0.679
Live-born piglets, n	15.24	15.71	0.468	0.544
Stillborn, n	1.80	1.94	0.144	0.590
TB litter birthweight, kg	23.32	24.05	0.511	0.330
TB Average birthweight, kg	1.37	1.44	0.028	0.112
TB within-litter standard deviation of birthweight, kg	0.31	0.32	0.011	0.311
LB litter birthweight, kg	21.52	22.88	0.538	0.080
LB average birthweight, kg	1.41	1.46	0.027	0.195
LB within-litter standard deviation of birthweight, kg	0.30	0.25	0.011	0.002
Placental efficiency	5.08	5.35	0.294	0.136

TB = total piglets born; LB = live-born piglets; SEM = standard error of the mean

The lack of effect of Gln supplementation on the number of pigs born is not surprising and may be related to the fact that the number of foetuses/piglets is primarily established during the initial third of gestation. Therefore, nutritional strategies after that period could have minimal or no effect on litter size at birth (Wu *et al*., 2013; Moreira *et al*., 2020).

No statistical difference was observed for average piglet weight; however, the litter weight of live-born piglets was improved by Gln supplementation in the gestating diet, which was linked to greater uniformity in those piglets. Modern sow lines have been developed to produce a larger litter, which has negatively affected within-litter uniformity with higher incidences of low-birth-weight piglets (Rooney *et al*., 2020). Those pigs are characterized by a higher risk of mortality and morbidity, poor performance, compromised growth during subsequent phases, and may even present reduced carcass and meat quality at slaughter (Alvarenga *et al*., 2013; Ashworth 2013; López-Vergé *et al*., 2018). In this context, strategies to improve piglet quality have focused on maternal nutrition, where Gln supplementation during gestation represents an opportunity to improve sow reproductive performance.

Glutamine has been associated with similar functions as arginine where supplementation can enhance foetal growth, reduce within-litter weight variation at birth, and prevent the occurrence of intrauterine growth restriction (Wu *et al*., 2010; Chen *et al*., 2018; Zhu *et al*., 2018). The mechanisms that explain Gln participation in foetal development are related to the synthesis of biologically-active molecules, such as nitric oxide and polyamines, which are important for placental blood flow, angiogenesis, and embryogenesis (Wu *et al*., 2013). Furthermore, Gln synthesized in the placenta serves as an important vehicle to transport nitrogen from mother to foetus; indeed, porcine placenta degrades high amounts of branched-chain amino acids (BCAAs) to synthesize Gln (Wu *et al*., 2017).

Because of this, Gln has been proposed as a conditionally essential AA for gestating sows (Watford, 2015).

As in the current study, Wu *et al*. (2011) reported that dietary supplementation of 1% Gln between day 90 and day 114 of gestation in gilts reduced the variation in piglet birth weight by 33%. More recently, in the study of Zhu *et al*., (2018), the variation in piglet birth weight was reduced by 18% as a result of feeding gestation diets supplemented with 1% Gln from day 85 of gestation until farrowing. In the same study, the average birth weight of live piglets was also improved. Collectively, data from the current study and previously published literature support the idea that dietary Gln supplementation improves litter uniformity, decreasing low birth weight piglets.

Based on the difference between the areas calculated from the lowest weight of each curve (Control and GLN; Figure 1) to the weight referring to the point of intersection between curves (equivalent to 1 480 g for both total and live-born piglet birthweight), birthweight probabilities were calculated. Dietary Gln supplementation reduced by 8.49 and 6.05 percentage points the probability of total born and live-born piglets weighing less than 1 480 g at birth, respectively (63.57% *vs* 55.08% and 59.82% *vs* 53.77%). Similarly, but now considering the other half of the curves, dietary Gln supplementation reduced by 8.49 and 6.05 percentage points the probability of total born and live-born piglets weighing more than 1 480 g at birth, respectively (36.43% *vs* 44.92% and 40.18% *vs* 46.23%). From the sum of the differences in the calculated areas, litter birthweight uniformity was improved by 16.98 (8.49% + 8.49%) and 12.12 (6.06% + 6.06%) percentage points for total born and live-born piglets from Gln supplemented sows.

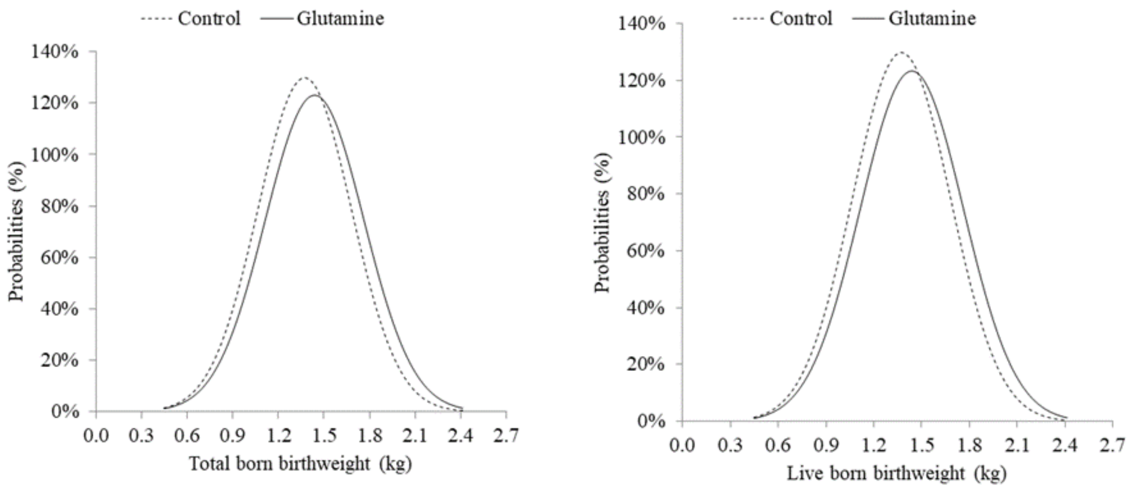

Figure 1 Distribution of weight probabilities at birth of total born and live-born piglets from sows supplemented or not with 1% L-glutamine during late gestation

During the lactation period, no differences were detected in maternal BW or body condition as a result of Gln supplementation (Table 4). Sow body condition was not influenced by dietary Gln supplementation during the lactation period, which was also reported by Kitt (2004), who observed no differences in body mobilization when comparing sows fed the control diet and sows fed Gln supplemented diet (2.5%). The current study reported no marked effect on lactation feed intake or milk production as a result of dietary 1% Gln supplementation. The close relationship between feed intake and body mobilization to support milk production during the lactation period is well-known and documented. Thus, variations in feed intake may affect the sow's body condition, where a high feed intake (> 5 kg/day) can prevent excessive BW loss, and otherwise, low sow feed intake (< 3 kg/day) is related to greater body mobilization (Baidoo *et al*., 1992; Mosnier *et al*., 2010). According to Strathe (2017), increasing feed intake by 1 kg/day reduced BW loss by 6.6 to 13.9 kg in parity 1 to 4 sows, respectively, during the lactation period. In the current study, lactation feed intake was not different between dietary treatments and could be considered high (> 6.7 kg/day), which explains the low body mobilization (< 5 kg during the entire lactation) and the lack of effect of dietary treatment on this variable.

There were no differences among dietary treatments for lactation average daily feed intake (ADFI) and milk production. Maternal Gln supplementation programs did not result in improved piglet growth performance throughout the suckling period (Table 5). Sow milk production and quality can be controlled by feeding strategies (Gessner *et al*., 2015; Strathe *et al*., 2017; Strathe *et al*., 2020). Costermans *et al*. (2020) provided modern sows with either full (6.5 kg/day) or restricted (3.25 kg/day) feed access in the last 2 w of the lactation period; compared to full-fed sows, restricted-fed sows had lower milk output and milk fat percentage, as well as lower litter weight gain and estimated milk fat and protein production. Thus, feed intake is directly related to milk production and piglet performance during the lactation period. In the current study, milk production was similar between treatments, probably because Gln supplementation did not affect sow feed intake, which in turn did not influence piglet growth performance during the lactation period. However, it was expected that dietary Gln supplementation during lactation would improve piglet performance due to the importance of this amino acid in mammary gland metabolism, milk production, and prenatal organ development (Li *et al*., 2009; Manso *et al*., 2012).

Table 4 Main effects of dietary L-glutamine supplementation during lactation on sow body condition, feed intake, and milk production

Parameters	CON_C	CON_G	GLN_C	GLN_GLN	SEM	*P*-value
BW day 2, kg	237.77	235.57	235.72	234.30	4.206	0.954
Backfat thickness day 2, mm						
P1 position	17.02	17.64	17.41	17.26	0.684	0.945
P2 position	15.02	14.99	14.59	14.96	0.555	0.955
Loin depth at day 2, mm						
P1 position	52.15	50.22	55.22	57.69	2.187	0.105
P2 position	47.22	43.91	47.5	46.54	1.411	0.304
BW at weaning, kg	240.11	238.42	234.25	236.24	4.888	0.866
Backfat thickness at weaning, mm						
P1 position	14.78	14.85	13.62	14.86	0.575	0.375
P2 position	14.08	14.02	12.89	14	0.575	0.444
Loin depth at weaning, mm						
P1 position	47.09	49.56	47.06	48.28	1.344	0.532
P2 position	45.15	43.25	46.42	45.85	1.048	0.207
BW change, day 2 to wean, kg	-1.68	-3.49	1.52	-4.21	3.464	0.682
BW change, day 2 to wean, %	-0.70	-1.57	0.48	-1.66	1.447	0.731
Lactation feed intake, kg/day	6.700	6.918	6.823	6.770	0.585	0.490
Milk production, kg/day	9.68	10.18	10.08	9.83	0.233	0.442

SEM = standard error of the mean; BW = body weight; CON_C: without Gln supplementation; CON_G: Gln only during lactation; GLN_C: Gln only during gestation; GLN_ GLN: Gln during gestation and lactation

Table 5 Main effects of dietary L-glutamine supplementation during lactation on pre-weaning performance

Parameters	CON_C	CON_G	GLN_C	GLN_GLN	SEM	*P*-value
Weaning age, days	20.22	19.60	19.67	19.71	0.210	0.244
Piglets per sow at day 2, n	12.80	12.39	12.47	12.58	0.172	0.369
Average piglet weight at day 2, kg	1.46	1.43	1.57	1.49	0.052	0.252
Within-litter SD at day 2, kg	0.20	0.18	0.21	0.22	0.013	0.219
Piglets per sow at weaning, n	11.84	11.58	11.89	12.00	0.250	0.795
Average piglet weight at weaning, kg	5.92	6.06	5.88	5.82	0.153	0.735
Within-litter SD at weaning, kg	1.04	1.02	1.17	1.14	0.061	0.281
ADG, kg/day	0.22	0.23	0.23	0.22	0.006	0.526
Pre-weaning mortality, %	6.93	4.63	4.57	4.38	1.576	0.732

2SEM = standard error of the mean; SD = standard deviation; CON_C: without Gln supplementation; CON_G: Gln only during lactation; GLN_C: Gln only during gestation; GLN_ GLN: Gln during gestation and lactation

Sow milk is characterized by high concentrations of Gln and this amino acid has been reported as important for the growth, development, and function of the neonatal small intestine (Kim & Wu 2009). Indeed, during the lactation period, the sow mammary gland produces 125% more Gln in milk than its uptake from arterial plasma, while BCAAs are highly catabolized (Trottier *et al*., 1997; Li *et al*., 2009). In addition, the sow mammary gland catabolizes other amino acids for Gln synthesis, which demonstrates the importance of Gln for the health and performance of the piglets. In this context, dietary Gln supplementation could be an effective strategy to provide the extra Gln required for milk production and even increase the Gln concentration in milk, preventing the use of other amino acids for Gln synthesis (Santos de Aquino *et al*., 2014). This hypothesis was tested by Manso *et al*., (2012) who demonstrated that dietary Gln supplementation (Aminogut, 2.5%) increased Gln and glutamate concentration in the milk of gilts with the potential to improve the growth of piglets throughout the suckling period (Wu *et al*., 2011). However, under the conditions of the current study, dietary supplementation of 1% Gln during the lactation period did not result in improved piglet growth performance.

Conclusions

Maternal Gln supplementation during late gestation improves piglet weight and litter uniformity at birth without affecting sow body composition after farrowing. Effects on sow or piglet performance during the lactation period were not evident in this study when the lactating diet was supplemented with 1% Gln under commercial conditions.

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Author contributions

LSF, RHRM, EL, RFC, and SRSJ collected the data for this study and analysis; LSF and JYPP wrote the initial draft of this manuscript; RHRM, TRG, LRSA, and CL reviewed and edited; MLTA, supervision. All authors have read and approved the finalized manuscript.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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