American Journal of Animal and Veterinary Sciences

Research Article

Production and Reproduction of Primiparous Guinea Pigs Concerning Lysine Levels

[1]Yasmeen Camila Vargas-Jauja, [1]Karin Marleny Casilla-Huallpa, [1]Liz Beatriz Chino-Velasquez, [2]Medardo Antonio Díaz-Céspedes, [3]Oscar Elisban Gómez-Quispe, [1]Jesús Camero-DeLaCuba, [1]Andrés Corsino Estrada-Zúñiga, [1]Gardenia Tupayachi-Solorzano and [1]Juan Elmer Moscoso-Muñoz

[1]*Faculty of Agronomy and Zootechnics, Universidad Nacional de San Antonio Abad del Cusco, Cusco, Peru*
[2]*Faculty of Zootechnics, Universidad Nacional Agraria de la Selva, Huánuco, Peru*
[3]*Faculty of Veterinary Medicine and Animal Science, Universidad Nacional Micaela Bastidas de Apurimac, Abancay, Peru*

Article history
Received: 08-01-2025
Revised: 12-03-2025
Accepted: 15-03-2025

Corresponding Author:
Juan Elmer Moscoso-Muñoz
Faculty of Agronomy and Zootechnics, Universidad Nacional de San Antonio Abad del Cusco, Cusco, Peru
Email: juan.moscoso@unsaac.edu.pe

Abstract: The development of breeding animals is essential to ensure the productivity of guinea pigs, so an adequate supply of nutrients is required. However, information on their nutritional requirements is limited, particularly with regard to amino acids such as lysine, wich affects their productive performance. We evaluated the effects of dietary lysine levels (0.84, 1.01, 1.18, and 1.34%) on primiparous guinea pigs and their progeny. We used a total of 60 female guinea pigs at 976±17.95 g. A randomized block design analysis was performed with four dietary treatments (lysine levels) and 15 repetitions/treatments. The results revealed that fertility showed a negative trend with the increase in lysine, the birth rate was highest (82%) with 1.18% lysine than others. The guinea pigs that received 1.18% lysine had young with the highest birth weight (206±4.4 g/guinea pig; $p<0.01$), and weight gain at weaning (197.7±8.9 g/guinea pig; $p<0.01$), but litter size was not influenced by lysine levels. Young mortality at weaning was high (18.2%) with a 1.34% lysine. The body weight of the breeders (gestation and lactation) was greater with 0.84 to 1.18% lysine ($p<0.01$), but there was a reduction with the 1.34% lysine level. A significant ($p<0.01$) reduction in feed intake was observed with 1.34% lysine during gestation, lactation, and weaning. The use of a level of 1.18% lysine in the diets of primiparous guinea pigs should be considered to improve the performance of females and the growth of their progeny.

Keywords: Amino Acid, Birth Rate, Fertility, Guinea Pig, Lysine, Reproductive Parameters

Introduction

The production of guinea pigs (*Cavia porcellus*) is an activity that is constantly increasing (consumption and demand) and, in the field of gastronomy, occupies a priority place in the Andean zone of Peru (Posada, *et al.*, 2015) and in some areas of South America, therefore the analysis of the productive performance of this species is of much interest for genetic selection programs (Tapie *et al.*, 2024). Currently, guinea pig breeding systems are improving, allowing for the development of earlier-maturing genetic lines, which implies a greater demand for nutrients, making it necessary to have adequate knowledge of their nutritional requirements at different breeding stages (Benítez-González *et al.*, 2019). The success of reproductive management occurs when there is correspondence with an adequate diet (Velásquez *et al.*, 2017). These dietary needs can not be met with forage alone; they require the use of balanced rations whose composition must continue to be studied to achieve maximum production (Carbajal Chávez, 2015).

Guinea pigs deliver precocial young after a relatively long pregnancy. Here, the capacity of the mother to deliver nutrients to the fetus is impaired since her reserves are depleted before conception (Elias *et al.*, 2016), affecting the reproductive and productive capacity of mothers in these conditions, the supplementation of dietary nutrients, such as lysine, could increase amino acid uptake by mammary cells that can be used for tissue and milk protein synthesis (Hurley *et al.*, 2000).

Protein plays a very important role, especially its constituents, amino acids and among them, lysine, which, when added to diets, increases muscle mass (Regmi *et al.*, 2016) and, during the prepubertal period, supports and balances the growth and reproductive

SCIENCE Publications

© 2025 Yasmeen Camila Vargas-Jauja, Karin Marleny Casilla-Huallpa, Liz Beatriz Chino-Velasquez, Medardo Antonio Díaz-Céspedes, Oscar Elisban Gómez-Quispe, Jesús Camero-DeLaCuba, Andrés Corsino Estrada-Zúñiga, Gardenia Tupayachi-Solorzano and Juan Elmer Moscoso-Muñoz. This open-access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

maturity (Seoane *et al.*, 2020; Tokach *et al.*, 2019) and obtain pregnancies in better conditions for both the mother and the young (Rezaei *et al.*, 2013; Wu, 2014). Improving the efficiency of protein utilization is important for pregnant animals due to its limited ability to support the growth of fetuses and mammary glands during late gestation and to support mammary growth and milk production, especially during the first lactation period (Kim *et al.*, 2009).

Gestation and lactation are the most important moments to guarantee a good litter size, pup uniformity, good weaning weight and body condition in breeding females (Gonçalves *et al.*, 2016), and it is undeniably the most metabolically demanding stage of production (Tokach *et al.*, 2019). Lactation constitutes the physiological stage of greatest nutritional demand since they need energy and protein (amino acids) for lactation and the growth of the young (Gonçalves *et al.*, 2016; Pedersen *et al.*, 2019). Therefore, nutrition must be adequate, supplying nutrients in sufficient quantity and quality, as is the case with proteins and mainly amino acids (lysine). The values and recommendations of amino acids given by the NRC are mainly oriented toward growing guinea pigs to produce maximal growth and nitrogen retention (Lang, 1995). Lozada *et al.* (2020) recommended the use of protein meals of animal origin to improve the weight of the litter at birth and the highest weight at weaning; however, amino acid requirements (lysine) for the pregnant/lactating and non-pregnant/non-lactating adult guinea pig have not been specifically determined (Lang, 1995).

Accurate estimation of amino acid requirements for gestation will allow nutritionists to set an advanced feeding strategy for gestating animals concerning improving lactation performance. Lysine is considered the first limiting amino acid in mammals and is essential for achieving good production and reproduction (Liao *et al.*, 2015), but the current knowledge is insufficient to draw a clear conclusion about the complex relationship between dietary lysine supply and plasma amino acids profiles (Liao, 2018). Thus, we aimed to evaluate the impact of different levels of lysine on guinea pigs during their first period of gestation and lactation and their effects on the young at birth and weaning.

Materials and Methods

Study Location and Duration

This study was conducted in a commercial guinea pig farm (Cusco – Peru) at an altitude of 3450 m above sea level and lasted 180 days. The daily temperature and relative humidity were 19.49±1.49°C and 41.62±3.75% respectively. Temperature and humidity were regulated using fans and heaters, which were used as needed. Lighting was natural and artificial (12 h/day). Cleaning was done three times a day to prevent the presence of insects and rodents, and traps were placed to control the presence of rodents. The analyses of the samples were carried out in the Nutrition, Food Science and Technology Laboratory of the Professional School of Zootechnics (Universidad Nacional de San Antonio Abad del Cusco, UNSAAC – Peru).

Animals and Housing

The experiment was conducted in an environmentally controlled house. A total of 72 improved type 1 guinea pigs of the inti line of approximately 30 day-olds (60 weaned females and 12 breeding males), with an initial Body Weight (BW) of 395.58±56.50 g in females, were used in the study; the number of young evaluated at birth was 164 animals to different experimental treatments. Guinea pigs were randomly accommodated in 12-floor pens of 1.2 m^2 (five females/pen); the males were also housed in individual metal pens (0.125 m^2/animal) and were placed with the females only for mating (Velásquez *et al.*, 2017). Each pen was provided with nipple drinkers and a manual feeder. During the experiment, guinea pigs were allowed free access to fresh water 24 h a day (Wolf *et al.*, 2020), and Feed was offered *ad libitum* in flour form.

Treatments, Experimental Diets and Feeding

Four levels of dietary lysine were used: T1: 0.84% lysine (100%), T2: 1.01% lysine (120%), T3: 1.18% lysine (140%) and T4: 1.34% lysine (160%). The lysine levels were modified according to the treatments proposed based on Lang's (1995) recommendations. The experimental diets were analyzed (Table 1) and supplied *ad libitum* (At 07:00 am), increasing progressively according to consumption. A daily record of the feed supplied and rejected was kept.

Reproduction, Calving, Lactation and Weaning

Breeders were first-calving females with a BW of 976±18 g., and the males that were mated with the females had an average BW of 1557±77 g, which remained for 30 days in each pen for the respective mating (Velásquez *et al.*, 2017). The registration and control of the number of young by birth, weight and time of birth were carried out, noting that the highest frequency of births took place in the afternoon and night (68%) than in the early morning and morning hours (32%), the duration of childbirth between calves was approximately seven minutes; the lactation lasted 17 days.

Sample Collection and Laboratory Analysis

The experimental diets were prepared by drying for 24 h at 60°C and then analyzed, following the guidelines of the AOAC (2005) Standardized Protocols for Animal Feed. Humidity using a forced convection oven (Binder, FED 720) at 135°C/2 h (AOAC 930.15). Ash with a muffle (Protherm, ECO 119) at 600°C/2 h (AOAC 942.05). Crude protein with an elemental analyzer CHNO/S (Perkin Elmer, 2400 Series II) (AOAC 990.03),

DOI: 10.3844/ajavsp.2025.103.111

crude fat with an automatic Soxhlet extractor (Hanon, SOX606) (AOAC 2003.05) and crude fibre, acid detergent fibre, neutral detergent fibre content were analyzed in a fibre analyzer (FIBRETHERM, FT12) (AOAC 978.10, AOAC 973.18 and AOAC 2002.04 respectively).

Table 1: Ingredients and nutritional value of the experimental diets (% As Feed); NFE Nitrogen Free Extract. GE Gross energy. DE Digestible energy. Premix (vitamins y minerals/kg) Vitamin A 9000 UI, Vitamin D3 2000 UI, Vitamin E 16.0 UI, Vitamin K 2.0 mg, Riboflavin 5.5 mg, Niacin 53.0 mg, D- Calcium pantothenate11.0 mg, Folic acid 0.1 mg, B.H.T. 100.0 mg, Manganese 112.0 mg, Zinc 100.0 mg, Iron 56.0 mg, Copper 7.0 mg, Iodine 1.0 mg, Selenium 0.1 mg.NFE Nitrogen-free extract. T1 100% level of lysine (0.84%), T2 120% level of lysine (1.01%), T1 140% level of lysine (1.18%), T1 160% level of lysine (1.34%)

Experimental diet	T1	T2	T3	T4
Ingredients				
Corn	13.81	13.41	12.99	12.55
Barley	28.34	28.69	29.06	29.44
Alfalfa meal	15.00	15.00	15.00	15.00
Soybean meal (44% CP)	15.77	15.13	14.46	13.76
Wheat by-product	6.29	6.76	7.26	7.77
Soybean oil	2.00	2.00	2.00	2.00
Oats	15.00	15.00	15.00	15.00
Limestone	0.866	0.868	0.870	0.872
Dicalcium phosphate	2.128	2.131	2.134	2.137
Salt	0.220	0.220	0.220	0.220
DL-Methionine, 99%	0.127	0.132	0.139	0.145
L-Lisyne	0.000	0.213	0.436	0.667
Sodium bicarbonate	0.242	0.240	0.238	0.236
Premix	0.100	0.100	0.100	0.100
Choline	0.100	0.100	0.100	0.100
Nutrients				
Dry matter	90.12	90.13	90.15	90.16
GE, kcal/kg	4055	4050	4125	4049
DE, kcal/kg	3031	3031	3032	3031
Crude protein	17.53	17.08	17.68	17.09
Ether extract	4.47	4.33	4.64	4.32
Crude fiber	8.43	8.46	8.49	8.52
NFE	54.92	55.68	55.95	55.62
Lysine	0.84	1.01	1.18	1.34
Methionine	0.39	0.39	0.39	0.40
Available phosphorus	0.50	0.50	0.50	0.50
Calcium	1.10	1.10	1.10	1.10

Variables Evaluated

The fecundity, birth rate, birth weight of the young, litter size, weaning weight, feed consumption, and weight gain in the young at weaning were evaluated. Additionally, the weight of the mothers was evaluated at birth, as well as weaning and mortality.

Data Analysis

A randomized block ANOVA analysis was performed to investigate the four dietary treatments (lysine levels). Differences were reported as significant at $p<0.05$, and means were compared using Tukey's test ($p<0.05$). The Pearson correlation and regression analysis were performed to establish the relationship between the birth weight and weaning weight. The Residual Standard Deviation (RSD) was used to indicate the variance of the observations in the relationship between the evaluated variables. To determine the error percentage, the comparison between the determined values and the regression estimates was used, calculating the Mean Square of the Predicted Error (MSPE) and the predicted error percentage, expressed as follows in Eqs. (1-2) (Nogueira *et al.*, 2021):

$$MSPE = \sum_{i=1}^{n} (Oi - Pi)\,\hat{}\,2/n \quad (1)$$

$$\%\mathrm{e} = \sqrt{\mathrm{MSPE}}\mathrm{x}\left(\frac{100}{\hat{y}}\right) \quad (2)$$

where, n is the total number of observations, Oi is the observed value, Pi is the predicted value, % e is the predicted error percentage, and $\hat{y}$ is the average of the observed values. Before the analysis, the assumptions of normality, variance homogeneity and independence were assessed. All data processing and analysis were performed using the Jamovi 2.4 software.

Results

Fertility and Birth

The females who received higher levels of dietary lysine had lower fertility than the control treatment, but their birth rate was highest at 1.18% of dietary lysine; in all cases, the increase in dietary lysine was associated with an improvement in the birth rate (Table 2).

Litter Size, Weight at Birth and Weaning

The litter size was similar between treatments, so it was not influenced by the level of dietary lysine. However, numerically larger litter sizes were obtained with 1.01 and 1.18% lysine. The weight of the young guinea pig at birth in all cases (average, females and males) increased as the lysine level was higher in the diet, being this maximum and higher with 1.18% compared to the others, observing a marked decrease in weight with 1.34%.

This same relationship was observed in the number of weaned young, where there was no effect of lysine level either. On the other hand, the weight of the young at birth (average) was higher with 1.18% lysine ($p<0.001$); this same effect was observed in female young and males in which the birth weight was higher with 1.18% lysine. These differences were maintained at weaning, where the weaning weight was higher ($p<0.001$) with 1.18%, which corresponds to 140% of the referential lysine level, both for the average in females and males. Regarding the weight gain during lactation until weaning, this was also higher with 1.18% lysine ($p<0.01$) when evaluated in the average for females and males (Table 2, Figure 1).

Table 2: Fertility, birth rate, litter size and weight variation at birth and weaning in young guinea pig

Variable	Lysine levels				P-Value
	0.84%	1.01%	1.18%	1.34%	
Fertility, %	100	80	86.7	86.7	-
Birth rate, %	74	74	82	78	-
Birth					
Litter size	2.8±1.3	3.4±1.3	3.4±1.1	3.0±0.8	0.530
Litter weight, g	172.1 c15.3	183.1 b±15	206.0 a±4.4	148.8 d±15.7	<0.001
Weight of females, g	164.5 c±14.9	179.7 b±13.5	203.2 a±8.2	147.3 d±17.6	<0.001
Weight of males, g	169.7 b ±17.5	178.1 b±17.1	207.3 a±15.0	140.1 c±10.4	<0.001
Weaning					
Number of young weaned	2.7±1.3	3.3±1.3	3.3±1.1	2.5±1.3	0.365
Young weight at weaning, g	333.1 b±44	329.8 b±26.5	403.0 a±4.7	296.5 c±40.5	<0.001
Females, g	323.0 b±31.6	327.6 b±30.6	399.2 a±8.2	297.0 c±55.5	<0.001
Males, g	331.0 b±44.7	320.2 b±28.1	404.1 a±5.4	277.4 c±14.2	<0.001
Weight gain, g	159.9 b±25.8	144.6 c±20.5	197.7 a±8.9	139.9 c±27.8	0.001
Females, g	157.7 b±20.6	147.8 b 22.0	196.0 a±4.1	146.5 b±44.3	0.001
Males, g	161.7 b±30.0	141.3 c±18.9	199.0 a±11.3	137.0 c±17.0	0.001

Based on the observed results, the relationship and/or effect of the birth weight of the young (females, males and on average) on their weaning weight was evaluated with all the recorded data (Table 3), where it could be seen that the estimated values of weaning weight had an adequate linear relationship (R^2 >75%) but a high RSD, this indicates that the model predicts weaning weight with less accuracy, which can be appreciated by the % error observed. These results show that weaning weight is influenced by the birth weight of guinea pigs. Therefore, it is important to achieve high birth weights, and one way to do this is to use lysine levels that are higher than those recommended by the NRC.

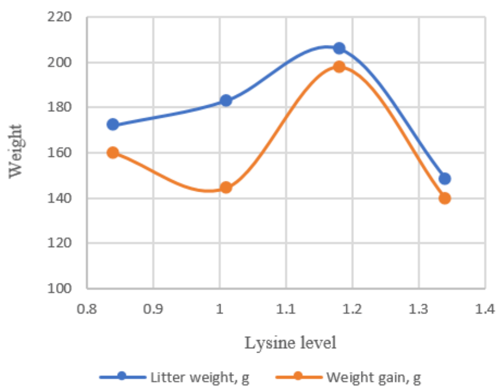

Fig. 1: Effect of lysine level on birth and weaning weight in guinea pigs

Table 3: Relationship between birth weight and weaning weight; Y Body weight; X Body weight at birth; S Standard deviation; R 2 Coefficient of determination; RSD Residual standard deviation; e Error; MSPE Mean square prediction error

	Female	Male	Average
Model	Y = 9.2+1.869 X	Y = 40.0+1.702 X	Y = 30.2+1.755 X
Observed	336.70	333.15	334.14
Predicted	333.10	333.20	334.37
R^2, %	76.33	75.55	76.04
S	24.13	26.90	25.67
RSD	19.52	20.49	18.39
MSPE	190.49	209.95	169.12
e, %	7.52	7.94	7.11

Live Weight and Weight Variation of Breeders

The weight was not influenced by variations in lysine levels from adaptation to completion of mating (Table 4); however, during gestation to parturition, differences were observed between treatments (p<0.01), the weight being significantly lower with the highest level of dietary lysine (1.34%) compared to the others, similar effects are reflected in the weight variation, where the lowest gain occurred with the 1.34% lysine (p<0.01). At the end of lactation (weaning), significant differences were also observed between treatments (p<0.01), the weight being lower with 1.34% lysine compared to the other treatments, but no differences were observed in weight variation, but it can be seen that the greatest weight loss was also recorded with the highest level of lysine.

Table 4: Body weight variation at different stages according to lysine concentration; BWG Body weight gain

Variable	Lysine level				P-Value
	0.84%	1.01%	1.18%	1.34%	
Body weight (g/animal)					
During adaptation	394.5±58.6	391.3±55.3	416.1±52.6	380.5±59.0	0.378
During mating	981.9±73.1	966.7±67.1	998.1±56.7	957.1±67.1	0.357
Gestation-Childbirth	1386.8 a±90.4	1398.7 a±98.5	1347.7 ab±127.0	1254.4 b±120.9	0.010
BWG	403.1 a±68.0	433.3 a±97.5	352.4 ab±104.6	297.2 b±102.9	0.005
Lactation-weaning	1379.5 a±104.9	1378.8 a±71.1	1334.5 ab±157.0	1195.7 b±171.2	0.003
BWG	-7.3±37.8	-19.9±51.4	-13.2±104.1	-58.7±111.2	0.274

Feed Intake (Dry Matter) in Breeders

Feed consumption was evaluated by taking into account the productive/reproductive stage (Table 5); thus, during breeding, no significant differences were observed between treatments. Regarding pregnancy and during lactation until weaning, significant differences (p<0.05) were observed between treatments, with lower consumption of 1.34% lysine (160%), not having observed differences for the other treatments.

Table 5: Variation in feed intake (dry matter) at different stages based on lysine level

Variable	Lysine level				P-Value
	0.84%	1.01%	1.18%	1.34%	
Consumption (g/animal, DM)					
Mating	2218.9±167.5	2273.8±93.4	2192.2±171.5	2142.6±80.6	0.697
Gestation	3631.3 a±141.4	3654.1 a±93.4	3602.8 a±171.5	3306.1 b±80.6	0.004
Lactation	2704.4 a±89.4	2516.3 a±37.0	2600.0 a±108.8	2216.0 b±89.9	0.001
Weaning	1966.4 a±85.1	1941.3 a±36.9	1921.4 a±91.2	1639.7 b±75.5	0.002

Mortality

The mortality in the breeders occurred during childbirth, being higher with the lowest level of dietary lysine (0.84%) with 13.3% and to a lesser extent with the level of 1.01% lysine, not having reported mortality with the highest levels; at the end of lactation (weaning) no mortality was recorded in any of the treatments. In the young guinea pig, the highest percentage of mortality at birth was at level 1.18% (8.0%) and 1.01% (7.5%) of lysine, but mortality at weaning was highest at 1.34% lysine level (18.2%) (Table 6).

Table 6: Mortality in mothers and young guinea pigs until weaning

Variable	Lysine level			
	0.84%	1.01%	1.18%	1.34%
Mothers				
During birth (%)	13.3	6.7	0	0
At weaning (%)	0	0	0	0
Young guinea pig				
At birth (%)	2.7	7.5	8.0	4.9
At weaning (%)	5.7	2.8	5.1	18.2

Discussion

The growth and health of the fetus and neonate are directly influenced by the nutritional and physiological status of the mothers (Yuan *et al.*, 2015). Therefore, the birth weight of the neonate is very important since it determines their survival and resistance capacity and has a marked influence on their productive behaviour, such as their weight at the end of lactation (weaning), final weight at slaughter and reproduction (Vázquez-Gómez *et al.*, 2018). In this case, the prediction models show that there is an influence of birth weight on weaning weight, but with less precision, which is reflected in the percentage of error it presents (>7%), attributable to the effect of variations in lysine levels.

The reduced weight gain observed with high lysine might be explained as increased oxidation of the amino acid requires an extra energy cost and therefore less net energy would be available for production (Urdaneta-Rincón and Leeson, 2008; Xiao *et al.*, 2019) when supplying amino acid over the immediate need for protein synthesis their oxidation increases (Matthews, 2020) and so the supplied of amino acids are more efficiently used for protein synthesis when supplied at moderate or requirement levels (Yang *et al.*, 2017) and also due to the lower consumption of nutrients observed due to the effect generated by the antagonistic interaction between lysine-arginine that had a primary effect of lysine in the regulation of food intake (Xiao *et al.*, 2019). Similar results have been observed in other animal species in which low levels of lysine depress growth, but the increase in lysine determines an improvement in weight gain and carcass yield (Hu *et al.*, 2022; Hussain *et al.*, 2018).

The number of weaned young was not influenced by variations in lysine levels, but weight and weight gain were significantly higher at 1.18%, and as for birth weight, the highest level of lysine determined a lower weight and weight gain for all cases (average, females and males). These results clearly show that there is a differentiated response depending on the lysine needs of guinea pigs during pregnancy and lactation and that this was reflected in the greater capacity of females to mobilize amino acids to the mammary gland with 1.18%, to be used for the synthesis of tissues and protein synthesis in milk, thus favouring the greatest availability of milk for the young (Elsaadawy *et al.*, 2022). However, when the lysine level exceeded the requirement, it would have generated a negative interaction between amino acids, altering the expected release of amino acids into the blood from diet, that excess dietary lysine increases the requirement for arginine (Liao *et al.*, 2015; Xiao *et al.*, 2019) and affects the metabolism and concentrations of almost all other amino acids (Zeng *et al.*, 2013; Liao *et al.*, 2015) such as histidine, isoleucine, taurine, threonine and valine (decreased) (Liao *et al.*, 2015).

Nutritional studies have shown that amino acids participate in and regulate key metabolic pathways to improve health, survival, immunity, growth, development, lactation, fertility, antioxidative responses and reproduction of the organisms (Wu, 2014). Additionally, variations in lysine consumption had an influence on metabolic status (Hosseintabar *et al.*, 2015) and reproductive hormone secretion (Xue *et al.*, 2012); in this way, high lysine intake improved the metabolic status and increased the total litter weight at birth and young weight at weaning (Hong *et al.*, 2020), which was observed in the present study with the 1.18% of lysine. The results of the study show that there is a need to adjust the levels of amino acids supplied in the diet of guinea pigs during gestation and lactation to optimize the use of dietary protein, with emphasis on females during their first pregnancy, in which the amino acids requirement is greater than multiparous (Hong *et al.*, 2020) and could be a strategy to improve the body weight and the reproductive performance (Seoane *et al.*, 2020) because a low voluntary feed intake during lactation results in an inadequate supply of dietary protein for fetal and mammary gland growth and also causes massive maternal tissue mobilization (Moullé and Parnet, 2019; Zhang *et al.*, 2019).

In the present study, the increase in dietary lysine levels had a negative effect on feed intake during pregnancy and lactation, but only with the highest level of lysine, the intake being similar to the other treatments, which implies that within the range from 0.84-1.18%, lysine did not generate adverse effects on the blood amino acid profile and would be within the optimal response range for animals (animal requirement), (Hong *et al.*, 2020), but with 1.34% a significant reduction in consumption was observed, which would have been determined by the alteration of the plasma amino acids profile because it is modified when there are changes in the dietary levels of amino acids (Liao, 2018); where the lysine is located at the top control level and their concentration in blood plasma increased linearly over a wide range of lysine content (Liao *et al.*, 2015), affecting the metabolism of almost all other amino acids, but is not influenced by others (Shikata *et al.*, 2007). Dietary lysine concentration may influence signalling pathways regulating food intake in the brain-liver axis via glutamate synthesis (Payne *et al.*, 2016).

The interaction between lysine and arginine is also known, where excess dietary lysine increases the requirement for arginine (Zampiga *et al.*, 2018; Nogueira *et al.*, 2021) and other interactions among amino acids within an animal body (Jansman *et al.*, 2019; Cemin *et al.*, 2019) alter the expected release of amino acids within into the blood from diet (Liao *et al.*, 2015), thereby affecting consumption, since the protein levels in the diets of the present study remained constant. This low consumption would not have allowed adequate nutrient intake, thus affecting their productivity, taking into account that the energy and amino acid requirements during this period are strongly increased (Tokach *et al.*, 2019).

These variations in consumption are reflected in the weight of the breeders at birth and weaning; during gestation in all treatments, a weight increase is observed, which is significantly higher in the first three treatments (0.84, 1.01 and 1.18%) compared to the highest level of lysine (1.34%), at the time of weaning the weight is lower too with 1.34% of lysine, but there were no differences in weight variation, however only with the level of 1.18% this variation was positive, being negative in the other treatments with greater emphasis with the level of 1.34% lysine, similar results were observed in studies with chickens and pigs where excess dietary lysine depresses weight gain in animals (Bouyeh, 2013; Aymerich *et al.*, 2020).

In the present study, mortality was recorded in mothers and young guinea pigs; in the case of mothers, this mortality occurred during childbirth but not during lactation (treatments with low lysine levels), the main cause being difficulty in childbirth. In young guinea pigs, mortality at birth was low and was not related to dietary lysine levels; however, during lactation and weaning, this mortality was high, with the highest level of lysine (1.34%) reaching over 18%. As indicated above, the imbalance of amino acids in the diet resulting from the excessive consumption of lysine would have determined a decrease in consumption and a change in the pattern of amino acids in plasma (Regmi *et al.*, 2016; Liao, 2018). These changes would have affected the transport of the growth-limiting amino acid, the concentration of which is already low in the blood, into the brain (Park, 2006), thereby generating a depression in consumption, decreased weight gain and possibly the death of the young guinea pig during lactation.

Currently, the technical breeding of guinea pigs is on the rise and feeding systems are evolving from the use of forages to balanced Feed. Meanwhile, advances in the genetics of this species have led to changes in their nutritional requirements. As a result, this study holds significant future implications for guinea pig farmers, offering valuable insights to enhance feeding practices, particularly during the reproductive and lactation stages.

Conclusion

Dietary lysine levels influence the reproductive and productive responses of breeders and young guinea pigs. The most favourable response was observed at the 1.18% lysine level, which improved fertility, birth rate, birth weight of the young, and weight and weight gain of the young at weaning. This response did not affect the weight of the breeders. However, an increase above this level produces adverse effects on mothers and young guinea pigs. It is necessary to continue studying the effect that amino acids have on the production and reproduction of guinea pigs to know their requirements, mainly limiting amino acids, considering physiological and genetic differences.

Acknowledgment

The authors thank the Nutrition, Food Science and Technology Laboratory of the Professional School of Zootechnics, UNSAAC. Cusco - Peru for the facilities provided in the development of the study.

Funding Information

Partial financial by the “Yachayninchis Wiñarinampaq” Research Strengthening Program through Resolution No. CU-103-2020-UNSAAC and Contract No. 004-2020-UNSAAC.

Author’s Contributions

Yasmeen Camila Vargas-Jauja: Methodology, investigation, resources, project administration, funding acquisition.

Karin Marleny Casilla-Huallpa: Methodology, investigation, resources, project administration, funding acquisition.

Liz Beatriz Chino-Velasquez: Conceptualization, methodology, investigation, writing-original draft preparation, writing-review and editing, funding acquisition.

Medardo Antonio Díaz-Céspedes: Data curation, writing original draft preparation.

Oscar Elisban Gómez-Quispe: Conceptualization, data curation, writing-original draft preparation, writing-review and editing.

Jesús Camero-DeLaCuba: Methodology, supervision, project administration.

Andrés Corsino Estrada-Zúñiga: Data curation, supervision.

Gardenia Tupayachi-Solórzano: Methodology, supervision.

Juan Elmer Moscoso-Muñoz: Conceptualization, formal analysis, data curation, writing original draft preparation, writing-review and editing, funding acquisition.

Ethics

All experimental procedures were approved by the Research Projects Approval Commission of the Professional School of Zootechnics, Faculty Agronomy and Zootechnics – UNSAAC (R-D-1231-2019-FCA) and followed national laws and National Research Council (NRC) guidelines for the care and use of laboratory animals (Hubrecht, 2011).

References

AOAC. (2005). *Official Method of Analysis*.

Aymerich, P., Soldevila, C., Bonet, J., Gasa, J., Coma, J., & Solà-Oriol, D. (2020). Increasing Dietary Lysine Impacts Differently Growth Performance of Growing Pigs Sorted by Body Weight. *Animals*, *10*(6), 1032. https://doi.org/10.3390/ani10061032

Benítez-González, E. E., Chamba-Ochoa, H. R., Calderón-Abad, Á. E., & Cordero-Salazar, F. B. (2019). Evaluación de bloques nutricionales en la alimentación de cobayos (*Cavia porcellus*) en etapas de crecimiento y engorde. *Journal of the Selva Andina Animal Science*, *6*(2), 66-73. https://doi.org/10.36610/j.jsaas.2019.060200066

Bouyeh, M. (2013). Effects of Excess Dietary Lysine and Methionine on Performance and Economical Efficiency of Broiler Chicks. *Annals of Biological Research*, *4*(5), 241-246.

Carbajal Chávez, C. S. (2015). *Evaluación preliminar de tres alimentos balanceados para cuyes (Cavia porcellus) en acabado en el Valle del Mantaro*.

Cemin, H. S., Tokach, M. D., Woodworth, J. C., Dritz, S. S., DeRouchey, J. M., & Goodband, R. D. (2019). Branched-chain amino acid interactions in growing pig diets1. *Translational Animal Science*, *3*(4), 1246-1253. https://doi.org/10.1093/tas/txz087

Elias, A. A., Ghaly, A., Matushewski, B., Regnault, T. R. H., & Richardson, B. S. (2016). Maternal Nutrient Restriction in Guinea Pigs as an Animal Model for Inducing Fetal Growth Restriction. *Reproductive Sciences*, *23*(2), 219-227. https://doi.org/10.1177/1933719115602773

Elsaadawy, S. A., Wu, Z., Wang, H., Hanigan, M. D., & Bu, D. (2022). Supplementing Ruminally Protected Lysine, Methionine, or Combination Improved Milk Production in Transition Dairy Cows. *Frontiers in Veterinary Science*, *9*, 780637. https://doi.org/10.3389/fvets.2022.780637

Gonçalves, M. A. D., Gourley, K. M., Dritz, S. S., Tokach, M. D., Bello, N. M., DeRouchey, J. M., Woodworth, J. C., & Goodband, R. D. (2016). Effects of amino acids and energy intake during late gestation of high-performing gilts and sows on litter and reproductive performance under commercial conditions1,2. *Journal of Animal Science*, *94*(5), 1993-2003. https://doi.org/10.2527/jas.2015-0087

Hong, J., Fang, L. H., & Kim, Y. Y. (2020). Effects of Dietary Energy and Lysine Levels on Physiological Responses, Reproductive Performance, Blood Profiles, and Milk Composition in Primiparous Sows. *Journal of Animal Science and Technology*, *62*(3), 334-347. https://doi.org/10.5187/jast.2020.62.3.334

Hosseintabar, B., Dadashbeiki, M., Bouyeh, M., Seidavi, A., Van den Hoven, R., & Gamboa, S. (2015). Effect of Different Levels of L-carnitine and Lysine-Methionine on Broiler Blood Parameters. *Revista MVZ Córdoba*, *20*(3), 4698-4708. https://doi.org/10.21897/rmvz.40

Hu, X., Huo, B., Yang, J., Wang, K., Huang, L., Che, L., Feng, B., Lin, Y., Xu, S., Zhuo, Y., Wu, C., Wu, D., & Fang, Z. (2022). Effects of Dietary Lysine Levels on Growth Performance, Nutrient Digestibility, Serum Metabolites, and Meat Quality of Baqing Pigs. *Animals*, *12*(15), 1884. https://doi.org/10.3390/ani12151884

Hubrecht, R. (2011). Guide for the Care and Use of Laboratory Animals, Eighth Edition 2011 The Committee for the Update of the Guide for the Care and Use of Laboratory Animals (2011). Published by the National Research Council of the National Academies, Washington DC, USA. 219 pp Paperback (ISBN 0-309-15400-6). Price US$19.95. *Animal Welfare*, *20*(3), 455-456. https://doi.org/10.1017/s0962728600003067

Hurley, W. L., Wang, H., Bryson, J. M., & Shennan, D. B. (2000). Lysine Uptake by Mammary Gland Tissue from Lactating Sows. *Journal of Animal Science*, *78*(2), 391. https://doi.org/10.2527/2000.782391x

Hussain, M., Mahmud, A., Hussain, J., & Qaisrani, S. (2018). Effect of Dietary Lysine Regimens on Growth Performance and Meat Composition in Aseel Chicken. *Brazilian Journal of Poultry Science*, *20*(2), 203-210. https://doi.org/10.1590/1806-9061-2017-0584

Jansman, A. J. M., Cirot, O., Corrent, E., Lambert, W., Ensink, J., & van Diepen, J. Th. M. (2019). Interaction and imbalance between indispensable amino acids in young piglets. *Animal*, *13*(5), 941-949. https://doi.org/10.1017/s175173111800263x

Kim, S. W., Hurley, W. L., Wu, G., & Ji, F. (2009). Ideal amino acid balance for sows during gestation and lactation1. *Journal of Animal Science*, *87*(suppl_14), E123-E132. https://doi.org/10.2527/jas.2008-1452

Lang, C. H. (1995). *Nutrient Requirements of Laboratory Animals.*Subcommittee on Laboratory Animal Nutrition, Committee on Animal Nutrition, Board on Agriculture, National Research Council. *The Quarterly Review of Biology*, *70*(4), 524-525. https://doi.org/10.1086/419223

Liao, S. F. (2018). Homeostatic regulation of plasma amino acid concentrations. *Frontiers in Bioscience*, *23*(2), 640-655. https://doi.org/10.2741/4610

Liao, S. F., Wang, T., & Regmi, N. (2015). Lysine nutrition in swine and the related monogastric animals: muscle protein biosynthesis and beyond. *SpringerPlus*, *4*(1). https://doi.org/10.1186/s40064-015-0927-5

Lozada, J. S., Villalva, J. G., Guerrero, P. V., & Loor, José Loor. (2020). Concentraciones de harina aviar en dietas para cuyes (cavias porcellus) en gestación y lactancia. *Journal of Science and Research*, *5*(2), 27-39. https://doi.org/10.5281/zenodo.3820518

Matthews, D. E. (2020). Review of Lysine Metabolism with a Focus on Humans. *The Journal of Nutrition*, *150*, 2548S-2555S. https://doi.org/10.1093/jn/nxaa224

Moullé, V. S., & Parnet, P. (2019). Effects of Nutrient Intake during Pregnancy and Lactation on the Endocrine Pancreas of the Offspring. *Nutrients*, *11*(11), 2708. https://doi.org/10.3390/nu11112708

Nogueira, B. R. F., Sakomura, N. K., Reis, M. de P., Leme, B. B., Létourneau-Montminy, M.-P., & Viana, G. da S. (2021). Modelling Broiler Requirements for Lysine and Arginine. *Animals*, *11*(10), 2914. https://doi.org/10.3390/ani11102914

Park, B.-C. (2006). Amino Acid Imbalance-Biochemical Mechanism and Nutritional Aspects. *Asian-Australasian Journal of Animal Sciences*, *19*(9), 1361-1368. https://doi.org/10.5713/ajas.2006.1361

Payne, A., Wang, X., Ivy, M. T., Stewart, A., Nelson, K., Darris, C., & Nahashon, S. N. (2016). Lysine mediation of neuroendocrine food regulation in guinea fowl. *Poultry Science*, *95*(2), 276-286. https://doi.org/10.3382/ps/pev326

Pedersen, T. F., Chang, C. Y., Trottier, N. L., Bruun, T. S., & Theil, P. K. (2019). Effect of dietary protein intake on energy utilization and feed efficiency of lactating sows1. *Journal of Animal Science*, *97*(2), 779-793. https://doi.org/10.1093/jas/sky462

Posada, S. L., Solarte, C. E., & Noguera, R. R. (2015). Efecto de la línea genética y el sexo sobre el crecimiento en cuyes (Cavia porcellus). *Livestock Research for Rural Development*, *27*(1).

Regmi, N., Wang, T., Crenshaw, M. A., Rude, B. J., Wu, G., & Liao, S. F. (2016). Effects of dietary lysine levels on plasma free amino acid profile in late-stage finishing pigs. *SpringerPlus*, *5*(1), 888. https://doi.org/10.1186/s40064-016-2463-3

Rezaei, R., Wang, W., Wu, Z., Dai, Z., Wang, J., & Wu, G. (2013). Biochemical and physiological bases for utilization of dietary amino acids by young Pigs. *Journal of Animal Science and Biotechnology*, *4*(1), 7. https://doi.org/10.1186/2049-1891-4-7

Seoane, S., De Palo, P., Lorenzo, J. M., Maggiolino, A., González, P., Pérez-Ciria, L., & Latorre, M. A. (2020). Effect of Increasing Dietary Aminoacid Concentration in Late Gestation on Body Condition and Reproductive Performance of Hyperprolific Sows. *Animals*, *10*(1), 99. https://doi.org/10.3390/ani10010099

Shikata, N., Maki, Y., Noguchi, Y., Mori, M., Hanai, T., Takahashi, M., & Okamoto, M. (2007). Multi-layered network structure of amino acid (AA) metabolism characterized by each essential AA-deficient condition. *Amino Acids*, *33*(1), 113-121. https://doi.org/10.1007/s00726-006-0412-0

Tapie, W. A., Posada-Ochoa, S. L., Rosero-Noguera, J. R., & Muñoz-Tamayo, R. (2024). Desarrollo de un modelo dinámico mecanicista para predecir el crecimiento de cuyes (Cavia porcellus) machos del genotipo Perúcir el crecimiento de cuyes (Cavia porcellus) machos del genotipo Perú. *Revista de La Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, *48*(189), 859-870. https://doi.org/10.18257/raccefyn.2997

Tokach, M. D., Menegat, M. B., Gourley, K. M., & Goodband, R. D. (2019). Review: Nutrient requirements of the modern high-producing lactating sow, with an emphasis on amino acid requirements. *Animal*, *13*(12), 2967-2977. https://doi.org/10.1017/s1751731119001253

Urdaneta-Rincón, M., & Leeson, S. (2008). Evaluation of Varied Dietary Crude Protein and Lysine Level at 5.7% of Crude Protein on Productive Parameters in Broiler Chikens. *Revista Científica*, *18*(2), 154-159.

Vázquez-Gómez, M., García-Contreras, C., Torres-Rovira, L., Astiz, S., Óvilo, C., González-Bulnes, A., & Isabel, B. (2018). Maternal undernutrition and offspring sex determine birth-weight, postnatal development and meat characteristics in traditional swine breeds. *Journal of Animal Science and Biotechnology*, *9*(1), 27. https://doi.org/10.1186/s40104-018-0240-6

Velásquez C., S., Jiménez A., R., Huamán C., A., San Martín H., F., & Carcelén C., F. (2017). Efecto de Tres Tipos de Empadre y Dos Tipos de Alimentación sobre los Índices Reproductivos en Cuyes Criados en la Sierra Peruana. *Revista de Investigaciones Veterinarias Del Perú*, *28*(2), 359. https://doi.org/10.15381/rivep.v28i2.13063

Wolf, P., Cappai, M. G., & Kamphues, J. (2020). Water consumption in small mammals (dwarf rabbits, Guinea pigs and chinchillas): New data about possible influencing factors. *Research in Veterinary Science*, *133*, 146-149. https://doi.org/10.1016/j.rvsc.2020.08.010

Wu, G. (2014). Dietary requirements of synthesizable amino acids by animals: a paradigm shift in protein nutrition. *Journal of Animal Science and Biotechnology*, *5*(1), 34. https://doi.org/10.1186/2049-1891-5-34

Xiao, C.-W., Wood, C., & Bertinato, J. (2019). Dietary supplementation with l-lysine affects body weight and blood hematological and biochemical parameters in rats. *Molecular Biology Reports*, *46*(1), 433-442. https://doi.org/10.1007/s11033-018-4492-1

Xue, L., Piao, X., Li, D., Li, P., Zhang, R., Kim, S. W., & Dong, B. (2012). The effect of the ratio of standardized ileal digestible lysine to metabolizable energy on growth performance, blood metabolites and hormones of lactating sows. *Journal of Animal Science and Biotechnology*, *3*(1), 11. https://doi.org/10.1186/2049-1891-3-11

Yang, Q.-Q., Suen, P. K., Zhang, C.-Q., Mak, W. S., Gu, M.-H., Liu, Q.-Q., & Sun, S. S.-M. (2017). Improved Growth Performance, Food Efficiency, and Lysine Availability in Growing Rats Fed with Lysine-Biofortified Rice. *Scientific Reports*, *7*(1), 1389. https://doi.org/10.1038/s41598-017-01555-0

Yuan, T., Zhu, Y., Shi, M., Li, T., Li, N., Wu, G., Bazer, F. W., Zang, J., Wang, F., & Wang, J. (2015). Within-Litter Variation in Birth Weight: Impact of Nutritional Status in the Sow. *Journal of Zhejiang University-SCIENCE B*, *16*(6), 417-435. https://doi.org/10.1631/jzus.b1500010

Zampiga, M., Laghi, L., Petracci, M., Zhu, C., Meluzzi, A., Dridi, S., & Sirri, F. (2018). Effect of dietary arginine to lysine ratios on productive performance, meat quality, plasma and muscle metabolomics profile in fast-growing broiler chickens. *Journal of Animal Science and Biotechnology*, *9*(1), 79. https://doi.org/10.1186/s40104-018-0294-5

Zeng, P. L., Yan, H. C., Wang, X. Q., Zhang, C. M., Zhu, C., Shu, G., & Jiang, Q. Y. (2013). Effects of Dietary Lysine Levels on Apparent Nutrient Digestibility and Serum Amino Acid Absorption Mode in Growing Pigs. *Asian-Australasian Journal of Animal Sciences*, *26*(7), 1003-1011. https://doi.org/10.5713/ajas.2012.12555

Zhang, S., Heng, J., Song, H., Zhang, Y., Lin, X., Tian, M., Chen, F., & Guan, W. (2019). Role of Maternal Dietary Protein and Amino Acids on Fetal Programming, Early Neonatal Development, and Lactation in Swine. *Animals*, *9*(1), 19. https://doi.org/10.3390/ani9010019