Open Veterinary Journal, (2026), Vol. 16(5): 2631-2640
Research Article
DOI: 10.5455/OVJ.2026.v16.i5.6

Submitted: 20/01/2026 Revised: 10/04/2026 Accepted: 20/04/2026 Published: 31/05/2026

Chicory (*Cichorium intybus* L.) and plantain (*Plantago lanceolata* L.) inclusion improves some growth, production, and carcass characteristics of guinea pigs (*Cavia porcellus* L.) in the Peruvian highlands

Shirley B. Pariona-Rodas[1], Misael Rodriguez[1], Flor L. Mejía[2], Medali Cueva-Rodríguez[3], Yolvi López[4], Héctor V. Vásquez[5], José A. Saucedo-Uriarte[5], Segundo J. Zamora-Huamán[2] and Ysai Paucar[2*]

[1]*Escuela Profesional de Ingeniería Agropecuaria, Facultad de Agronomía y Zootecnia, Universidad Nacional de San Antonio Abad del Cusco, Andahuaylas, Perú*
[2]*Laboratorio de Nutrición Animal y Bromatología de Alimentos, Instituto de Investigación en Ganadería y Biotecnología, Facultad de Ingeniería Zootecnista, Biotecnología, Agronegocios y Ciencia de Datos, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Chachapoyas, Perú*
[3]*Laboratorio de Patología Veterinaria, Facultad de Ciencias Veterinarias, Universidad Nacional de Cajamarca, Cajamarca, Perú*
[4]*Instituto Nacional de Innovación Agraria, Estación Experimental Andenes, Cusco, Perú*
[5]*Laboratorio de Agrostología, Instituto de Investigación en Ganadería y Biotecnología, Facultad de Ingeniería Zootecnista, Biotecnología, Agronegocios y Ciencia de Datos, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Chachapoyas, Perú*

ABSTRACT

Background: Alternative forages, such as chicory and plantain, have been successfully applied in various animal species. As a result, these forages could serve as an alternative for raising guinea pigs in high Andean regions; however, few, if any, reports have been published on the effects of their inclusion on growth, production, and carcass yield.
Aim: This study aimed to determine the effects of incorporating chicory and plantain into the diet of guinea pigs on growth, production, and carcass yield, elucidating the possibility of using these species for feeding guinea pigs.
Methods: The study was conducted in Andahuaylas—Perú, in an experimental period of 6 weeks. Five guinea pigs were randomly assigned to each diet treatment (30% chicory–70% lucerne, 30% plantain–70% lucerne, 50% chicory–50% lucerne, 50% plantain–50% lucerne, and 100% lucerne as a control). Growth, production, and carcass yield were measured. Covariance analysis was performed using R software, and the means were compared using Dunnett's method ($\alpha = 0.05$).
Results: Diets with chicory (30%–50%) improved the final live weight, weight gain, feed conversion ratio, and hot carcass weight, whereas diets with plantain (30%) improved the final live weight, dry matter intake, feed conversion ratio, and carcass weight compared with diets with 100% lucerne.
Conclusion: Chicory and plantain can optimize the growth, production, and hot carcass weight of guinea pigs in high Andean areas, surpassing traditional lucerne diets.
Keywords: Carcass, *Cichorium intybus*, Growth, Guinea pig, *Plantago lanceolata*.

Introduction

The guinea pig (*Cavia porcellus* L.) is a species of rodent mammal native to the Andes of South America, and its breeding represents an important source of economic income for many Peruvian families (Avilés *et al.*, 2014). Guinea pigs represent a food resource of high nutritional value, being an important source of animal protein (Bazay *et al.*, 2014; Cáceres *et al.*, 2021). Traditionally, guinea pig farming occurred within families in small spaces in the yards of low-income rural populations (Avilés *et al.*, 2014). However, in recent years, it has shown a sustained increase in demand due to its high protein and low-fat contents, which are 19.49% and 3.67%, respectively (Guevara Vásquez *et al.*, 2021; Huaman *et al.*, 2021; Barreto, 2024). According to a recent report from 2017, a total of 827,234 livestock farmers produced 21,103 tons of guinea pig meat (INEI, 2017). This increase in

***Corresponding Author:** Ysai Paucar. Laboratorio de Nutrición Animal y Bromatología de Alimentos, Instituto de Investigación en Ganadería y Biotecnología, Facultad de Ingeniería Zootecnista, Biotecnología, Agronegocios y Ciencia de Datos, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Chachapoyas, Perú. Email: ysai.paucar@untrm.edu.pe

demand represents a challenge for family farms, which must move toward a more technologically advanced operation that guarantees productive performance and the quality of the final product (Morales, 1994; Meza Bone *et al.*, 2014; Huaman *et al.*, 2021). As Meza *et al.* (2014) pointed out, the productive capacity of the guinea pig is improved when there is an adequate feeding system because it directly influences growth, feed conversion, and the nutritional quality of the meat obtained.

The main feed sources in the diet of guinea pigs in the high Andean zone of Peru, under family or family-commercial breeding systems, are based on green forages, such as lucerne, clover, and concentrate or mixed diets (Chauca, 2007; Huamaní *et al.*, 2016). The problem with forage-based feeding is that its availability and quality vary throughout the year, and the land available for its cultivation becomes a limiting factor (Chauca, 2007). In that sense, it is necessary to explore other types of feed that maintain a stable economic and nutritional value despite the dry season or drought.

Several studies have indicated that plantain (*Plantago lanceolata* L.) and chicory (*Cichorium intybus* L.) are good alternatives; even under unfavorable environmental conditions, they can grow, maintain their nutritional quality, and have a high annual yield of dry matter per hectare (Cranston *et al.*, 2015; Minneé *et al*., 2019; Rattanasomboon *et al.*, 2019; Rodríguez *et al.*, 2020). Furthermore, these species possess medicinal properties due to the presence of secondary compounds beneficial to animals; chicory has been shown to exhibit immunostimulatory, antimicrobial, antioxidant, hyperlipidemic, and anti-inflammatory biological activity (Rodríguez *et al.*, 2020; Seidavi *et al.*, 2021; Saeed *et al.*, 2022). Plantain is also a species recognized for its medicinal effects, having anti-asthmatic, dyspneic, and antitussive properties (Boskabady *et al.*, 2006). These characteristics, combined with their nutritional value, make them a good alternative for feeding guinea pigs.

The contribution of plantain and chicory to animal nutrition in various species has been studied. In Australia, Rodríguez *et al.* (2020) found that mixed grazing of plantain and chicory improves the quality of lamb milk and meat by increasing polyunsaturated fatty acids (PUFA), eicosapentanoic acid 20:5n-3 (EPA), and docosahexanoic acid 22:6n-3 (DHA) contents. In Sweden, chicory has been shown to be a highly digestible and palatable fibrous ingredient in the feeding of chickens and pigs (Liu *et al.*, 2013). Similarly, a diet supplemented with 0.5% plantain positively affected broiler chicken growth, feed intake, feed conversion ratio, performance index, and carcass characteristics (Chacrabati *et al.*, 2013). However, studies on the effects of including chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) in the diet of guinea pigs are scarce. Therefore, this study aimed to determine the effect of incorporating chicory and plantain into the diet of guinea pigs on their growth, production, and carcass yield, contributing to the proper use of chicory and plantain in guinea pig diets.

Materials and Methods

This research was conducted at the Choccepuquio farm, belonging to the School of Agricultural Engineering of the Universidad Nacional de San Antonio Abad del Cusco, located at 2,853 m above sea level, 73°24'28.22" west longitude and 13°40'8.66" south latitude, in the Peruvian highlands. The average annual temperature is 9.3°C, and the annual rainfall is 1,474 mm (Climate Data, 2025). Rainfall is concentrated from November to April and coincides with the highest temperatures, whereas rainfall decreases and temperatures are lowest from May to October.

Experimental design

Twenty-five one-month-old male Andina guinea pigs with an average (SD) weight of 0.329 (0.036) kg were housed in individual cages measuring 0.5 × 0.45 × 0.40 m. Each cage was equipped with a clay feeder and automatic waterers to ensure constant water access. The selected animals were previously fed 100% lucerne diet.

Five treatments were designed: 100% lucerne (100 Lu), 30% chicory and 70% lucerne (30 Ch_70 Lu), 30% plantain and 70% lucerne (30 Pl_70 Lu), 50% chicory and 50% lucerne (50 Ch_50 Lu), and 50% plantain with 50% lucerne (50 Pl_50 Lu). Treatment with 100% lucerne was considered as the control. The nutritional composition of chicory, plantain, and lucerne used in this experiment was also evaluated in four samples for each at the Laboratorio de Nutrición Animal y Bromatología de Alimentos of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas. The species influenced all nutritional characteristics, except for the crude protein, which was similar between species (Table 1).

Five guinea pigs were randomly assigned to each treatment in a completely randomized design, and the study was conducted in 2 stages: habituation and evaluation. The habituation period lasted for 5 days, during which the diets were provided according to the assigned treatments. Each guinea pig received 0.5 kg of diet daily to guarantee ad libitum feeding, half in the morning (8:00 am) and the remainder in the afternoon (3:00 pm). This feeding routine was the same as that for the evaluation period. The evaluation period lasted for 6 weeks. The animals' initial live weight (ILW) was recorded, and the amount of feed provided, and any remaining feed was recorded daily.

Productive parameters

The live weight of the animals was recorded weekly before feeding using a scale with a reading capacity of 0.001 kg. Samples of each diet were oven-dried at 105°C for 24 hours, and dry matter intake was

Table 1. Means (standard deviation) of the nutritional composition of chicory, plantain and lucerne used in this experiment (n = 4/ species).

Characteristic	Chicory	Plantain	Lucerne	*p*-value
Dry matter percentage	12.2 (1.72)^{c}	16.07 (1.72)^{b}	24.44 (1.74)^{a}	[1.08E-05]
Ash (%)	11.88 (0.43)^{a}	12.02 (0.82)^{a}	8.1 (0.2)^{b}	[4.24E-06]
Ether extract (%)	2.45 (0.12)^{a}	1.84 (0.22)^{b}	2.45 (0.27)^{a}	[0.00345]
Crude protein (%)	20.84 (0.4)^{a}	19.29 (0.52)^{a}	19.91 (2.06)^{a}	[0.261]
Crude fiber (%)	18.05 (0.37)^{a}	11.39 (0.95)^{b}	20.87 (3.02)^{a}	[0.00014]
Neutral detergent fiber (%)	22.92 (0.24)^{b}	33.4 (0.74)^{a}	31.94 (1.47)^{a}	[1.69E-07]
Acid detergent fiber (%)	19.44 (0.12)^{b}	25.11 (0.23)^{a}	28.49 (3.54)^{a}	[0.0005]

Between brackets are the *p*-value of analysis of variance. Different letters within the row indicate significant differences according to the Tukey test (α = 0.05).

calculated weekly by subtracting the feed residue from the offered feed.

The weight gain was calculated weekly by subtracting the initial weight from the final weight. Daily weight gain was estimated from this data by dividing the weekly gain by the number of days (7). The feed conversion ratio was calculated by dividing dry matter intake by weight gain.

Carcass yield

The animals were fasted for 12 hours (Kouakou *et al.*, 2013), their live weight at slaughter (LWS) was recorded, and they were immediately slaughtered. The animals were stunned with a neck hit (Sánchez-Macías *et al.*, 2016), and the jugular and carotid veins were immediately punctured for exsanguination. A trained personnel member manually performed scalding in hot water, after which the viscera (digestive tract and bladder) were removed. The hot carcass weight (HCW) was measured on a scale with a reading capacity of 0.001 kg 20 minutes after slaughter (Sánchez-Macías *et al.*, 2016). The carcass included the skin, feet, head, and red viscera (heart, lung, liver, spleen, diaphragm, and kidneys). Perirenal fat was subsequently removed, and its weight was recorded. The hot carcass yield (HCY) was determined as the ratio between the HCW and LWS (de Figueiredo *et al.*, 2020).

Data analysis

An exploratory analysis of the data was performed, and the absence of outliers was verified. Furthermore, the assumptions of normality and homoscedasticity were verified using the Kolmogorov–Smirnov and Levene's tests, respectively, which were successfully met. Covariance analysis was performed on the growth, productive, and carcass yield characteristics using a linear model that included the treatments as a factor and the initial live weight as a covariate. When evidence of differences between treatments was found, the means of the treatments were compared with the control group (100 Lu), for which Dunnett's method was used (Dunnett, 1955) in the PMCMRplus package (Pohlert, 2024). The null hypothesis was that the mean of all variables (except for dry matter intake and fed conversion ratio) was less than or equal to that of the control group. For dry matter intake and feed conversion ratio, the null hypothesis was that the control group's mean was greater than or equal to the treatments' mean. A one-way analysis of variance was performed to evaluate the nutritional composition of the forages, including the species as a factor. When significant differences were found, Tukey's method was used to compare means. The free software R v. 4.5.1 (R Core Team, 2025) was used for all data analysis, and a significance level of 0.05 was used; in addition, graphs were made with the ggplot2 package (Wickham, 2016).

Ethical approval

The study was designed in strict compliance with Law No. 30407 (Animal Protection and Welfare Law—Peru) and was approved by the Institutional Ethics Committee for Research of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas (CIEI-No. 00243).

Results

Growth and productive parameters

The live weight of the animals increased in all treatments from the beginning until week 6 (Fig. 1). During the 6 weeks of evaluation, the 30Ch_70Lu and 30Pl_70Lu treatments showed greater live weight than the control group ($p < 0.05$), whereas the remaining treatments (50Ch_50Lu and 50Pl_50Lu) showed no differences ($p > 0.05$) compared to the control group.

Regarding weekly dry matter intake, the 100 Lu treatment was superior to the 30Pl_70Lu, 50Ch_50Lu, and 50Pl_50Lu treatments ($p < 0.05$) in all weeks, except for week 3, in which it was similar to 30Pl_70Lu ($p > 0.05$). In contrast, the dry matter intake of 100 Lu and 30Ch_70Lu was similar ($p > 0.05$) in all weeks, except for week 1, in which 100 Lu outperformed 30ch_70 Lu ($p < 0.05$) (Fig. 2).

Weekly and daily weight gain followed a similar pattern. In weeks 1, 2, and 5, 50Ch_50Lu outperformed 100 Lu ($p < 0.05$); in week 1, 30Ch_70Lu and 30Pl_70Lu showed higher values than the control. No significant

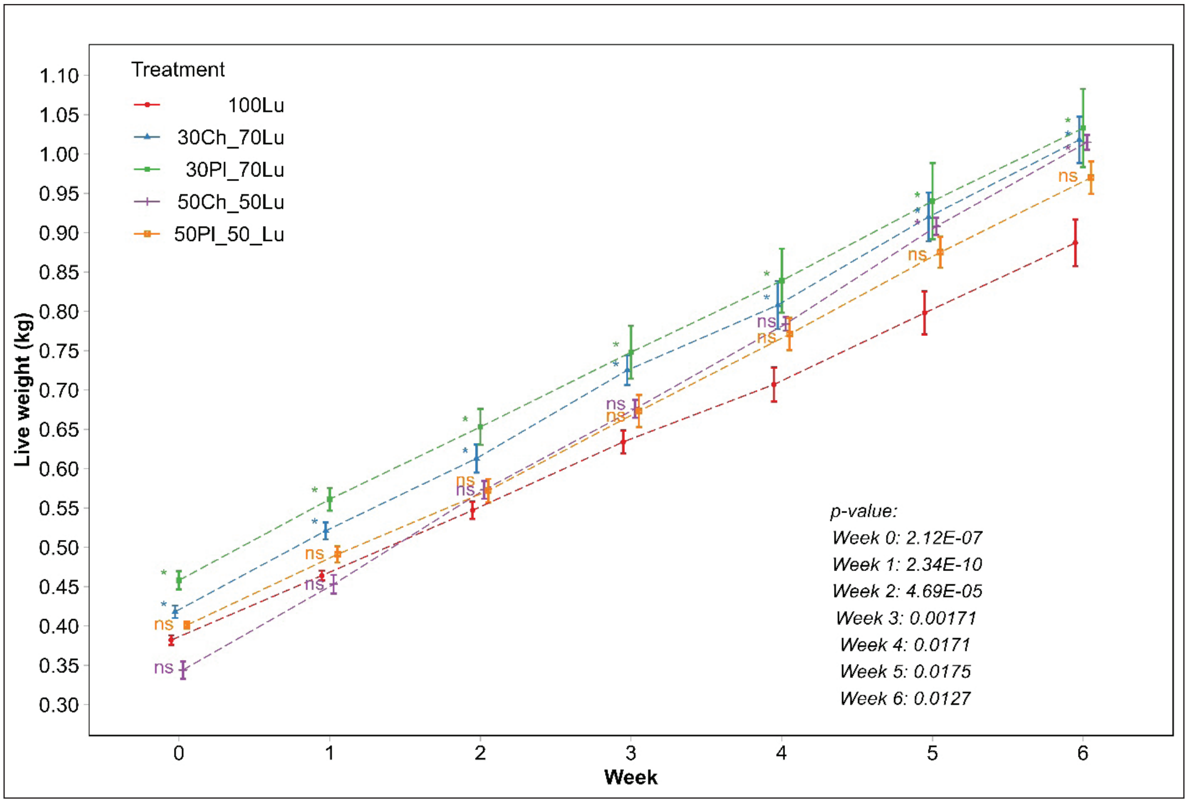

Fig. 1. Growth of guinea pigs fed with chicory and plantain at different inclusion levels. The bars represent the standard error. *, within a week indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne.

differences were detected in weeks 3, 4, and 6 (Figs. 3 and 4).

The feed conversion ratio was higher in the 100 Lu group during weeks 1, 4, 5, and 6 ($p < 0.05$), while in week 2, the 50Ch_50Lu and 50Pl_50Lu groups had lower values than the control. No differences were found between the experimental diets and the control at week 3 (Fig. 5).

Throughout the evaluation period, initial weight, final weight, total dry matter intake, total weight gain, daily weight gain, and feed conversion ratio were influenced by the type of feed ($p < 0.05$). The final weight, total weight gain, and daily weight gain for the 30Ch_70Lu and 50Ch_50Lu treatments were higher than those for the 100 Lu treatment; they also had lower feed conversion ratios (Table 2).

Carcass characteristics

The hot carcass weight of 30Ch_70Lu, 30Pl_70Lu, and 50Ch_50 Lu was higher than that of the control (100 Lu) ($p < 0.05$); however, the control was similar to that of the 50Pl_50Lu treatment ($p > 0.05$). In contrast, the live weight at slaughter, hot carcass yield, and perirenal fat weight of guinea pigs fed chicory, or plantain, were similar ($p > 0.05$) to those fed 100% lucerne (Table 3).

Discussion

This study evaluated the effect of including chicory and plantain in different proportions on the productive parameters and carcass yield of guinea pigs over 6 weeks. Treatments containing 30% chicory or plantain resulted in greater weight gain and better feed conversion ratio compared with the control group (100% lucerne). These results are consistent with those of studies conducted in guinea pigs and sheep. In guinea pigs, the inclusion of alternative forages improved the conversion efficiency and final live weight (Barreto, 2024), whereas in ewes' milk and in lambs' fat (Rodríguez *et al.*, 2020), there were higher concentrations of polyunsaturated fatty acids. In this sense, the type and proportion of forage is an important variable because it is related to the availability of nutrients and the presence of secondary compounds that influence the digestibility of the feed and the development of the guinea pigs (Minneé *et al.*, 2019). The nutritional composition of the studied forages (chicory, plantain, and lucerne) was as follows: dry matter percentage (12.2%, 16.07% and 24.44%),

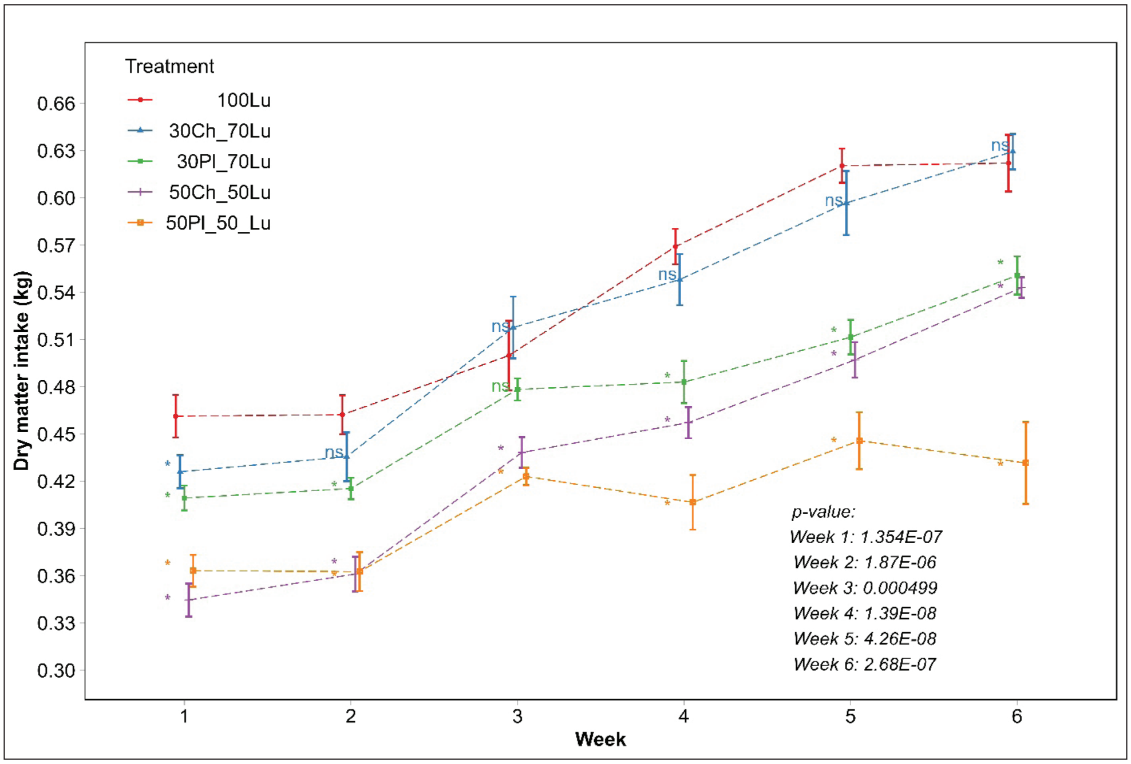

Fig. 2. Weekly dry matter intake of guinea pigs fed with different chicory and plantain inclusion levels. The bars represent the standard error. *, within a week indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne.

ash (11.88%, 12.08% and 8.10%), ether extract (2.45%, 1.84%, and 2.45%), crude protein (20.84%, 19.29%, and 19.91%), and crude fiber (18.05%, 11.39%, and 20.87%) (Table 1). Chicory and plantain showed low values of dry matter percentage, high values of ash, and similar values of crude protein compared with lucerne. Therefore, chicory and plantain can be incorporated as alternative forages in the diet of guinea pigs in the appropriate proportions. This represents a good alternative to traditional forages that decrease in nutritional value or become scarce during the dry season, thus increasing their price (Chauca, 2007; Ivarsson *et al.*, 2012; Cáceres *et al.*, 2021).

The changes in dry matter intake and weight gain in relation to the guinea pigs that consumed only lucerne could be related to the nutritional composition of each forage. The dry matter percentage of chicory and plantain was lower than that of lucerne; the crude fiber of plantain was lower than that of chicory and lucerne; and the neutral and acid detergent fibers of chicory were lower than those of plantain and lucerne, but the latter showed similar values (Table 1). In this regard, Minneé *et al.* (2019) indicated that a diet consisting of plantain has a lower amount of dry matter and structural fiber but a higher amount of non-structural fiber than Ryegrass pastures, which means that they have a greater availability of easily fermentable carbohydrates. Similarly, Cranston *et al.* (2015) reported that green forages, such as chicory, plantain, and clover, can produce high-quality dry matter even during the summer and fall, indicating that diets based on these forages can increase animal production rates. This aligns with the results of this study, where diets containing chicory and plantain improved production indicators compared to a diet consisting solely of lucerne.

Furthermore, the greater weekly and daily weight gain achieved in guinea pigs with the 50Ch_50Lu, 30Ch_70Lu, and 30Pl_70Lu treatments could be related to greater digestibility and intestinal health influenced by chicory and plantain consumption. Liu *et al.* (2013) and Rattanasomboon *et al.* (2019) found that chicory, due to its high pectin content, can improve the digestibility of certain fiber fractions and modulate the intestinal microbiota in young pigs, although it can decrease digestibility in birds at high inclusion levels. In this study, the different crude fiber, neutral, and acid detergent fiber contents of chicory and plantain (Table 1) may have improved their digestibility. Although these results provide some insight into the

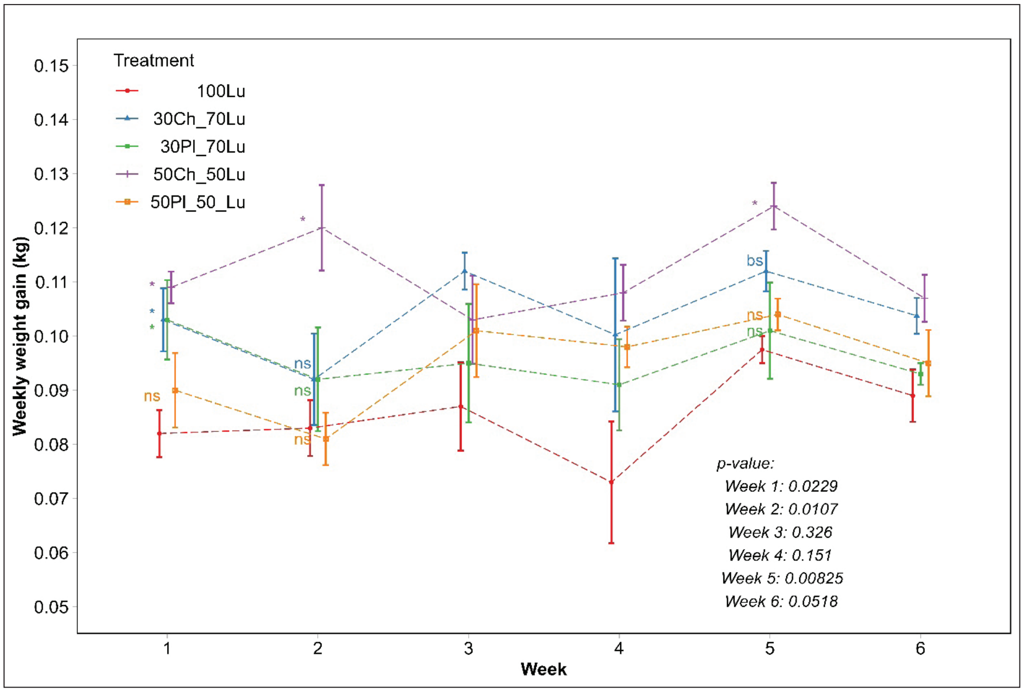

Fig. 3. Weekly weight gain of guinea pigs fed with different chicory and plantain inclusion levels The bars represent the standard error. *, within a week indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne.

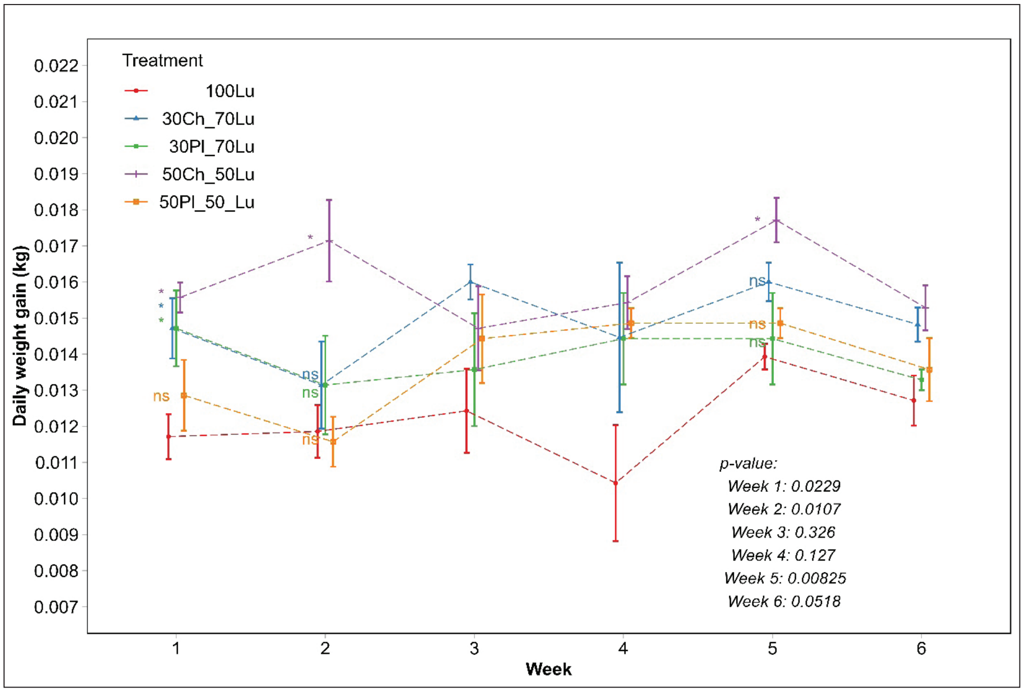

Fig. 4. Daily weight gain of guinea pigs fed with different chicory and plantain inclusion levels The bars represent the standard error. *, within a week indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne.

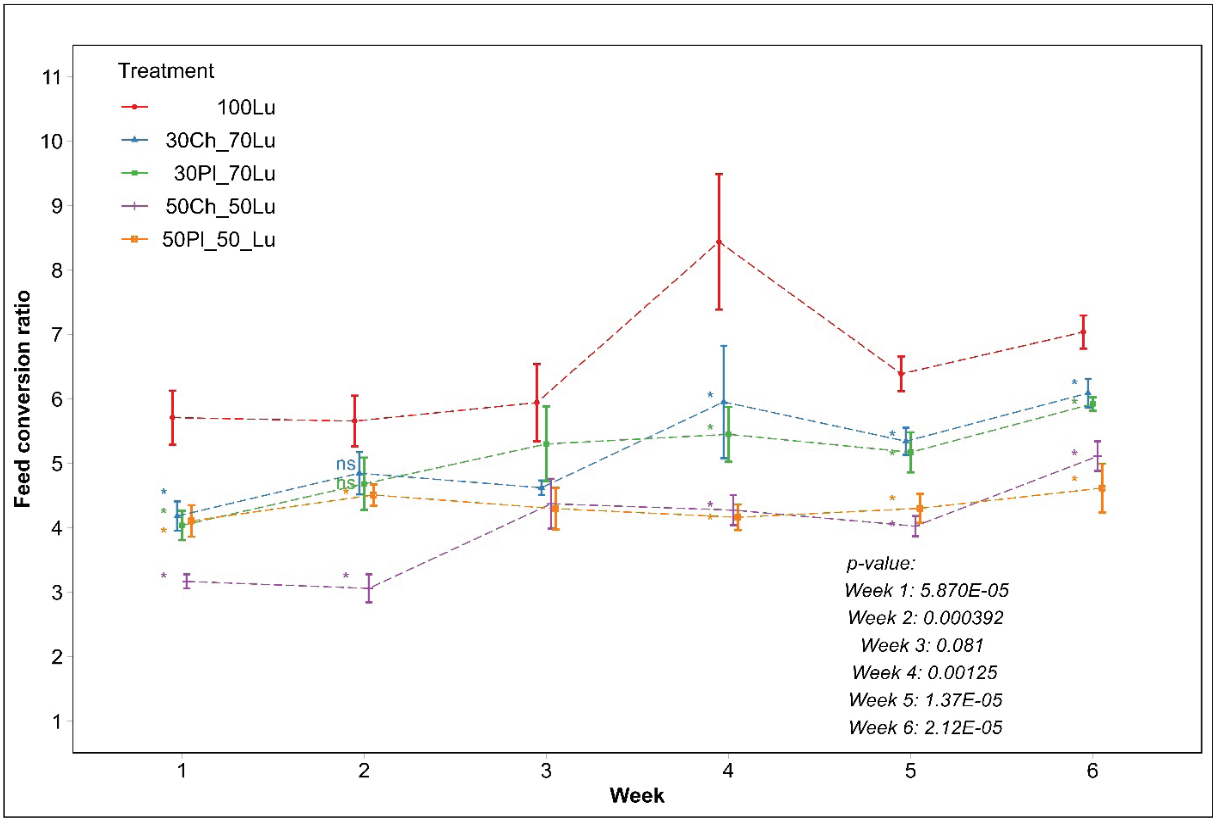

Fig. 5. Feed conversion ratio of guinea pigs fed with different chicory and plantain inclusion levels The bars represent the standard error. *, within a week indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne.

Table 2. Global (42 days) means in bold SE of the productive performance of guinea pigs fed with different levels of chicory and plantain inclusion (n = 5/treatment).

	ILW (kg)	**FLW (kg)**	**DMI (kg)**	**TWG (kg)**	**DWG (kg/day)**	**FCR**
Treatment	**[2.12E-07]**	**[0.0127]**	**[9.58E-09]**	**[0.0119]**	**[0.0119]**	**[1.98E-05]**
100 Lu	0.382 (0.014)	0.887 (0.066)	3.230 (0.127)	**0.505** (0.068)	0.012 (0.002)	6.500 (0.902)
30Ch_70Lu	0.418 (0.018)*	1.020 (0.066)*	3.150 (0.193)ns	0.600 (0.063)*	0.014 (0.002)*	5.300 (0.634)*
30Pl_70Lu	0.458 (0.026)*	1.030 (0.111)*	2.850 (0.114)*	*0.575* (0.095)ns	0.014 (0.002)ns	5.030 (0.614)*
50Ch_50Lu	0.344 (0.025)ns	1.020 (0.021)*	2.640 (0.103)*	0.671 (0.033)*	0.016 (0.001)*	3.950 (0.314)*
50Pl_50Lu	0.401 (0.010)ns	0.970 (0.047)ns	2.430 (0.180)*	0.569 (0.038)ns	0.014 (0.001)ns	4.280 (0.201)*
Total	0.401 (0.042)	0.985 (0.083)	2.862 (0.337)	0.584 (0.080)	0.014 (0.002)	5.012 (1.056)

Between brackets are the *p*-value of analysis of variance. *, within a column indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); ns, non-significant differences. 100 Lu, 100% lucerne; 30Ch_70Lu, 30% chicory and 70% lucerne; 30Pl_70Lu, 30% plantain and 70% lucerne; 50Ch_70Lu, 50% chicory and 50% lucerne; 50Pl_50Lu, 50% plantain and 50% lucerne. ILW, initial live weight; FLW, final live weight; DMI, dry matter intake; DWG, daily weight gain; TWG, total weight gain; FCR, feed conversion ratio.

Table 3. Means (SD) of carcass characteristics of guinea pigs fed with different chicory and plantain inclusion levels (n = 3/treatment).

	LWS(kg)	HCW (kg)	HCY (%)	PRFW (g)
Treatment	**[0.0977]**	**[0.0357]**	**[0.691]**	**[0.375]**
100 Lu	0.848 (0.073)	0.587 (0.04)	69.228 (1.407)	3.943 (1.245)
30Ch_70Lu	0.988 (0.092)	0.703 (0.048)*	71.295 (2.491)	5.510 (1.457)
30Pl_70Lu	1.032 (0.115)	0.721 (0.072)*	70.028 (5.004)	5.620 (0.674)
50Ch_50Lu	0.955 (0.038)	0.687 (0.05)*	71.839 (2.422)	5.127 (0.603)
50Pl_50Lu	0.915 (0.005)	0.630 (0.005)[ns]	68.889 (0.119)	3.960 (1.913)
Total	0.948 (0.091)	0.666 (0.066)	70.256 (2.644)	4.832 (1.321)

Between brackets are the p-value of analysis of variance. *, within a column indicates significant differences to the Dunnett test (α = 0.05) that compares the inclusion of chicory and plantain with de control (100% lucerne); [ns], non-significant differences. 100 Lu, 100% lucerne;

effect of chicory on the microbiota and digestibility of some animals, further studies in guinea pigs are needed to fully understand its effect. Dicksved *et al.* (2015) and Abate *et al.* (2022) reported that plantain contains bioactive compounds with antioxidant, anti-inflammatory, and antibacterial properties that can influence the microbiota and immune parameters. Therefore, the improvement observed in weight gain and feed conversion in this study could be associated with these effects on digestibility and microbiota, although specific studies are required to confirm this.

On the other hand, the effect of chicory and plantain on the guinea pig carcass was also evaluated. Only the hot carcass weight was significantly influenced by the treatments. No significant differences were found between the experimental treatments and the control in terms of live weight at slaughter, hot carcass yield, and perirenal fat weight, which coincides with findings in broiler chickens and quail supplemented with plantain and chicory (Chacrabati *et al.*, 2013; Temur and Usla, 2019), where improvements in live performance were observed without marked changes in carcass characteristics. This suggests that the inclusion of these forages can improve productive efficiency without altering carcass composition, although some studies in sheep have shown improvements in the fatty acid profile of the meat when the animals are grazed on chicory and plantain (Rodríguez *et al.*, 2020).

Conclusion

The incorporation of chicory (30% or 50%) and plantain (30%) improves the growth characteristics, production, and carcass weight of guinea pigs compared with a 100% lucerne diet. Therefore, chicory and plantain show good potential for improving guinea pig production, especially in high Andean areas, such as the Apurímac region (Peru).

Acknowledgments

None.

Conflict of interest

The authors declare no conflict of interest.

Funding

This research received no specific grant.

Authors' contributions

Conceptualization, Ysai Paucar and M. Rodriguez; methodology, Shirley B. Pariona-Rodas; formal analysis, José A. Saucedo-Uriarte and Flor L. Mejía; investigation, Shirley B. Pariona-Rodas and Yolvi López; data curation, Ysai Paucar and Héctor V. Vásquez; writing-original draft preparation, Medali Cueva-Rodríguez and Segundo J. Zamora-Huamán; writing-review and editing, all authors; visualization, Yolvi López; supervision, Ysai Paucar. All authors have read and agreed to the published version of the manuscript.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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