



Digestibility of pisonay (*Erythrina edulis*) meal. An alternative supplement in guinea pigs (*Cavia porcellus* L.)

Digestibilidad de la harina de pisonay (*Erythrina edulis*). Un suplemento alternativo en cuyes (*Cavia porcellus* L.)

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Article Data

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Abstract

The nutritional composition and digestibility coefficient of Pisonay meal were determined. Three male guinea pigs were used, distributed in individual metabolic cages for each age of regrowth. The guinea pigs received the feed mixture under 18 % isoprotein conditions, consisting of pisonay meal and maize meal, 64.0:36.0, 66.3:33.7 and 73.5:26.5, in a habituation phase and a faecal collection phase, each lasting 7 days, 2 replicates were performed for each guinea pig. Data were analysed using confidence intervals. Dry matter was 92.0 %, total protein and neutral detergent fibre decreased from 22.2 to 20.7 %, from 22.2 to 20.7 % and from 46.0 to 44.7 %, ethereal extract and total ash were around 1 and 9 % respectively. Non-fibre carbohydrates increased from 21.1 to 24.0 % and crude energy was around 4.2 Mcal kg⁻¹ dry matter. Digestibility coefficient of dry matter, crude protein and neutral detergent fibre and neutral detergent digestible fibre and digestible energy decreased from 50.1 to 45.8 %, from 62.1 to 46.2 %, from 24.9 to 20.6 % and from 1.87 to 1.61 Mcal kg⁻¹ respectively. The age of regrowth caused a decrease in the nutritional components and digestibility of pisonay meal, and its protein and energy content could be included as a non-conventional protein ingredient for guinea pig feeding.

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Resumen

Se determinaron la composición nutricional y el coeficiente de digestibilidad de harina de Pisonay. Se utilizaron 3 cobayas machos, distribuidos en jaulas metabólicas individuales para cada edad de rebrote. Las cobayas recibieron la mezcla alimenticia en condiciones isoproteicas del 18 %, compuesta por harina de pisonay y harina de maíz, 64.0:36.0, 66.3:33.7 y 73.5:26.5, en una fase de habituación y otra de recogida de heces, cada una con 7 días de duración, se realizaron 2 réplicas para cada cobaya. Los datos se analizaron mediante intervalos de confianza. La materia seca fue del 92.0 %, la proteína total y la fibra detergente neutro disminuyeron del 22.2 al 20.7 %, del 22.2 al 20.7 % y del 46.0 al 44.7 %, el extracto etéreo y la ceniza total rondaron el 1 y el 9 % respectivamente. Los hidratos de carbono no fibrosos aumentaron del 21.1 al 24.0 % y la energía bruta se situó en torno a 4.2 Mcal kg⁻¹ de materia seca. El coeficiente de digestibilidad de la materia seca, la proteína bruta y la fibra detergente neutro y la fibra detergente neutro digestible y la energía digestible disminuyeron del 50.1 al 45.8 %, del 62.1 al 46.2 %, del 24.9 al 20.6 % y del 1.87 al 1.61 Mcal kg⁻¹ respectivamente. La edad de rebrote provocó una disminución de los componentes nutricionales y de la digestibilidad de la harina de pisonay, y su contenido proteico y energético podría incluirse como ingrediente proteico no convencional para la alimentación de cobayas.

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Introduction

Grasses have low nutritional quality, and influenced by high temperature and radiation, would quickly cause their maturation and lignification, on the other hand, forage varieties with better nutritional profile, such as alfalfa, which had negative effects on productivity in response to climatic anomalies and periods of drought¹. The behaviour of *Erythrina* species, such as *Erythrina americana* foliage, the age of regrowth (60, 90 and 120 days) affected crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF)² contents, climatic conditions in the dry season in the foliage caused an increase in dry matter (DM 32.3 %) and a decrease in NDF (45.6 %), compared to the rainy season (25.9 and 50.6 % respectively), in addition, a stable production of 14.0 % in CP was maintained³ and in the rainy season *E. poeppigiana*, without considering the age of regrowth, showed that the CP content is between 16.8 to 20.9 %, in addition, its NDF content is 47.0 %^{4,5}. In Apurímac 2012, with respect to the national population of guinea pigs, they represented approximately 8.0 % and their guinea pig production was carried out through family and commercial family farming systems⁶, currently it is reported that the national population of guinea pigs increased to 17.38 million, 45.6 % are raised by small and medium producers and 25.1 %, on a large scale⁷. In this process, their feeding has played an important role, one of the feeding systems is based on balanced feed, plus fresh fodder *ad libitum*⁸, the latter would provide vitamin C⁹, another is to supply fodder and vegetable residues from agriculture, with the aim of producing animal protein at low cost¹⁰. In addition, we have the use of non-conventional feeds for guinea pig feeding, such as fresh fodder from the foliage of *E. poeppigiana*¹¹

and the processing of *E. edulis* leaves into meal, which was included as a protein input¹².

The use of forage tree legumes is an available resource that contributes to the sustainability and efficiency of the production system, improves the quantity and quality of the diet, which will be beneficial for animal feed, and stands out for its protein content (15.7-18.3 %) and digestible energy (3.1 Mcal kg⁻¹)¹³, nutritional levels that could cover the requirements for guinea pigs. Guinea pigs have a functional caecum where fermentation occurs and according to the nutritional quality of the forage, it was observed that the grass *Phleum pratense*, both fresh and dry, denoted a convenient digestibility of NDF (76 and 71 %) and FDF (72 and 67 %)¹⁴ and *E. poeppigiana* harvested from the forage (72 and 67 %). *E. poeppigiana* harvested at 55 days in the rainy season, due to its notable protein content (17 %) would have a DM digestibility (47.2 %) and structural components (NDF 43.6 and FDA 26.2 %), this behaviour would indicate that it could be a feasible option for animal feed¹⁵.

In order to improve and achieve advantages in guinea pig productivity, the search for alternative feeds continues, including non-conventional feeds. The pisonay (*E. edulis*) as fresh forage at different ages of regrowth, 4 and 12 months, it was observed that the DM content tended to increase to 28.1 % and CP decreased to 20.1 %, at older ages there was a stability in the NDF content close to 58.0 %¹⁶ and the digestible energy was estimated at 2.6 Mcal kg⁻¹ DM¹⁷. These variations prompted us to evaluate the nutritional composition, apparent digestibility coefficient (DC) and estimate the digestible energy of *E. edulis* leaf meal at different regrowth ages (4, 8 and 12 months).

Materials and methods

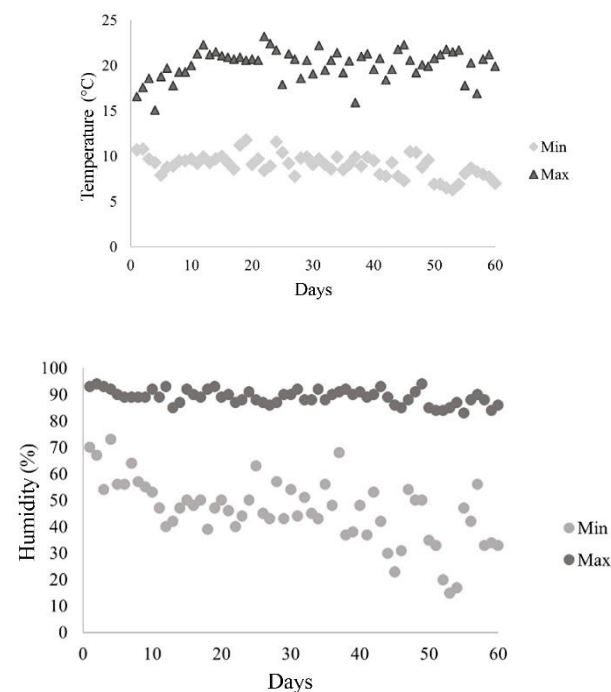
The edible biomass of pisonay trees (*E. edulis*) of different regrowth ages (4, 8 and 12 months) from the last cut, from trees located in live fences and used for animal feed in Mosoccpampa, Abancay, was pruned. The edible biomass consisted of leaves and petioles of the trees, which were subjected to a natural drying process under shade. After approximately 30 days, they were milled in a hammer mill with a 2 mm sieve. In the maize and pisonay meal, as well as in the faeces, the nutritional composition was determined according to AOAC¹⁸. NDF and FDA were determined by Van Soest et al.¹⁹. Non-fibre carbohydrates (NFC), by arithmetic difference of the 4 components determined²⁰, $NFC = 100 - [CP + (\text{ether extract}) EE + (\text{total ash}) CT + NDF]$ and crude energy (GE) by the formula of Nehring & Haenlein²¹, $GE = 5.72 \times CP + 9.50 \times EE + 4.79 \times \text{crude fibre (CF)} + 4.03 \times \text{extract free of nitrogen (ELN)}$.

The nutritional evaluation of feed and faeces was carried out at the Laboratory of Nutrition and Animal Feeding, Professional Programme of Veterinary Medicine and Zootechnics of the Catholic University of Santa Maria (UCSM), Arequipa, Peru.

The guinea pigs were sourced from the Del Corral farm (commercial breeding) located in Abancay, in good health and health assessment was carried out once a week throughout the experiment. Three male guinea pigs (replicates) with a live weight (BW) of 1004.3 ± 92.0 g (coefficient of variability, CV = 9.1 %), with an approximate age of 3 months, were used for each age of regrowth of the feed mix, which were placed in individual metabolic cages of 0.16 m^2 , with movable feeders and drinkers located on the outside

of the cage. The cages were placed on a table covered with white formica to facilitate cleaning.

Figure 1 Temperature and humidity during the experiment, adapted according to SENAMHI 2022



The guinea pigs received the feed mixture, in proportions of 64.0:36.0, 66.3:33.7 and 73.5:26.5 (Table 1), constituted by the different regrowth ages (4, 8 and 12 months)¹⁶ of pisonay meal (HP) plus maize meal, based on the nutritional composition of the inputs and according to the nutritional requirements, it was considered 18.0 % protein²² and coated vitamin C (Pro-Premix Nutrition SRL) was added in the amount of 0.5 g kg^{-1} of feed²³. This feed mixture was fed ad libitum once a day in the morning, in addition to clean, fresh water daily. The experiment was carried out in the facilities of the Biochemistry Laboratory of the Faculty of Veterinary Medicine and Animal Husbandry of the Universidad Nacional Micaela Bas-

tidas de Apurímac (UNAMBA), Abancay, Peru. After 5 days of adaptation of the guinea pigs to the metabolic cages, a 7-day feed habituation phase and 7 days of faeces collection were started. The guinea pigs were subjected to natural light for approximately 12 h, the ambient temperature was between 21 and 24° C and the relative humidity was around 60 % (wall-mounted thermohydrometer).

Table 1 Calculated nutritional composition of the feed mix, according to proportions of pisonay flour and corn flour

Indicator	HP4M:HM 64.0:36.0	HP8M:HM 66.3:33.6	HP12M:HM 73.5:26.5
MS, %	91.32	91.43	91.62
PT, % MS	18.02	18.02	18.02
EE, % MS	1.64	1.59	1.67
CT, % MS	6.32	6.65	7.03
FDN, % MS	33.46	34.59	35.74
FDA, % MS	19.91	20.54	21.45
CNF, % MS	40.55	39.14	37.52
EB, Mcal kg ⁻¹ MS	4.29	4.28	4.28

In both stages, the feed offered and not consumed, consisting of residues and wastes, as well as the amount of faeces, all adjusted to DM, were recorded. Apparent digestibility (AD) was performed by conventional in vivo digestion by total faecal collection and the formula was used:

$$\text{CDA (\%)} = \frac{\text{Nutrient ingested} - \text{Nutrient excreted}}{\text{Nutrient ingested}} \times 100$$

The DM of the feed mixture and faeces of each guinea pig were previously determined, quantified, mixed, ground and analyzed.

For the digestible energy, first, the digestible energy content of the feed mixture (ED_A) was determined, using the following formula:

$$\text{ED}_A \text{ (Mcal/kg MS)} = \frac{\text{EB consumed (Mcal)} - \text{EB excreted (Mcal)}}{\text{MS consumed (g)}}$$

Subsequently, the ED of the different regrowth ages (4, 8 and 12 months) of the HP (ED_{HP}) was estimated according to the following formula:

$$\text{ED}_{HP} \text{ (Mcal/kg MS)} = 100 \times \left[\frac{\text{ED}_A - \text{ED}_M}{\%S} \right] + \text{ED}_M$$

The ED of maize (ED_M = 3.85 Mcal kg⁻¹ DM) proposed by Castro & Chirinos²⁴ and the percentage of substitution (% S) of 64.0, 66.3 and 73.5 % for each age of regrowth were used.

In the determination of the nutritional composition of feed and faeces, as well as digestibility, 2 replicates were carried out for each guinea pig.

For the composition of the HP of each regrowth age and apparent digestibility coefficient (DC) for each nutrient and digestible energy, the average was used and the confidence interval was calculated.

Results

Table 2 shows the nutritional composition of HP (*E. edulis*). DM ranged from 91.9 to 92.9 % at all 3 regrowth ages. The TP decreased 0.4 % between 4 and 8 months and 1.0 % between 8 and 12 months of regrowth age. At all 3 regrowth ages, EE and TC remained around 1.0 and 9.0 % respectively. NDF expressed a similarity of 46.0 % for 4 and 8 months and decreased to 44.8 % at the age of 12 months. FDF was similar (29.4 %) at ages 4 and 8 months and at 12 months decreased to 26.5 %. NFP remained close to 21.0 % at 4 and 8 months and increased by approximately 3.0 % at the age of 12 months. In the 3 ages of regrowth, the behaviour of BS was between 4.19 to 4.34 Mcal kg⁻¹ of DM.

Table 3 shows the percentage of digestibility of the nutrients evaluated by CD. The CDMS between the

ages of 4 and 8 months decreased by 1.0 % and between the ages of 4 and 12 months it decreased by 4.4 % and in the CDPT the detriment was observed

due to the effect of the maturity stage of 62.1, 58.2 up to 46.2 %.

Table 2 Nutritional composition of the three regrowth ages of pisonay flour (*Erythrina edulis*)

Indicator	4 months			8 months			12 months		
	\bar{X}	LI	LS	\bar{X}	LI	LS	\bar{X}	LI	LS
MS, %	92.45	92.14	92.76	92.51	92.31	92.70	92.45	91.91	92.98
PT, % MS	22.22	19.94	24.50	21.81	20.87	22.75	20.71	19.47	21.96
EE, % MS	1.14	1.04	1.24	1.11	.96	1.28	1.36	.96	1.76
CT, % MS	9.13	8.79	9.46	9.35	7.86	10.83	9.08	8.38	9.79
FDN, % MS	46.28	45.22	47.34	46.73	45.72	47.73	44.78	42.28	47.29
FDA, % MS	29.49	28.58	30.39	29.49	28.26	30.72	28.14	26.50	29.79
CNF, % MS	21.21	18.58	23.83	20.99	19.94	22.03	24.04	21.52	26.55
EB, Mcal kg ⁻¹ MS	4.29	4.23	4.34	4.27	4.19	4.34	4.27	4.22	4.32

\bar{X} , Average. LI, Lower limit. LS, Upper limit. 95% confidence interval, DM dry matter, PT total protein, EE ether extract, TC total ash, NDF neutral detergent fiber, FDA acid detergent fiber, CNF non-fiber carbohydrates, GE gross energy. Mcal megacalories.

Table 3 Apparent digestibility of the three regrowth ages of pisonay flour (*Erythrina edulis*)

Indicator	4 months			8 months			12 months		
	\bar{X}	LI	LS	\bar{X}	LI	LS	\bar{X}	LI	LS
CDMS, %	50.14	48.62	51.67	49.14	46.68	51.60	45.79	44.71	46.87
CDPT, %	62.12	52.94	71.29	58.20	56.50	59.90	46.28	40.38	52.19
CDEE, %	16.76	9.90	23.62	31.00	7.76	54.25	15.60	1.80	33.02
CDCT, %	30.09	27.18	33.01	43.58	39.73	47.41	39.74	38.04	41.44
CDFDN, %	24.98	24.20	25.77	21.08	18.50	23.64	20.69	18.28	23.10
CDCNF, %	70.06	68.60	71.53	71.45	67.49	75.40	71.94	70.34	73.54
ED, Mcal kg ⁻¹ MS	1.88	1.68	2.06	1.74	1.50	1.98	1.61	1.50	1.72

\bar{X} , Average. LI, Lower limit. LS, Upper limit. 95% confidence interval, CDMS coefficient of digestibility of dry matter, CDPT coefficient of digestibility of total protein, CDEE coefficient of digestibility of ether extract, CDCT coefficient of digestibility of total ash, CDFDN coefficient of digestibility of neutral detergent fiber, CDCNF coefficient of digestibility of non-fiber carbohydrates, ED digestible energy. Mcal megacalories.

At 8 months of regrowth age, EE and CT, had the highest digestibility percentage, at 12 months CDEE decreased to 11.0 % and CDCT at 4 months reached 30.0 %. The CDFDN at 4 months of regrowth age was around 25.0 %, it was observed that at 8 months it decreased by 3.9 % and at 12 months by 4.3 %.

CDCNF due to the effect of maturity stage tended to increase between the ages of 4 and 8 months by 1.4 % and between the ages of 4 and 12 months by 1.9 %. Digestible energy tends to decrease by 0.13 Mcal kg⁻¹ DM between the three regrowth ages.

Discussion

The DM of HP was similar to the value reported for *Moringa oleifera*²⁵. The TP level was lower than that reported in *E. americana* (25.6 %) ²⁶, with the foliage of *Erythrina* sp. harvested at 4 and 12 months of regrowth age, values that reached 26.0 % and 23.0 % respectively 16,17 being at values (>20.0 %) reported in flours derived from shrub foliage²⁷.

Regarding NDF and FDF of HP, they presented values below 52.0 and 34.0 % respectively reported in the foliage of *E. americana*²⁶ and 58.0 % of NDF determined in *Erythrina* sp.¹⁵, with a similarity in the

NDF of flours obtained from shrub foliage that had values of 30.0 to 50.0 %²⁷.

The ash content of HP was lower than that of *E. variegata*, which in the rainy period reached (19.0 %)²⁸.

The EB of HP in the 3 ages of regrowth was below 4.68 Mcal kg⁻¹ DM reported in the leaves of *E. glauca*, it should be noted that this value was found by adiabatic calorimetric pump²⁹.

HP, due to its protein percentage and the fibre observed, could be considered an alternative as an input in the elaboration of food for guinea pigs, this behaviour would be corroborated by the values of PT 19.0 to 35.0 %, FDN 26.0 to 58.0 % and FDA 27.0 to 43.0 % found in several species of *Erythrina*³⁰, in addition, it is mentioned that tree species with levels of CP 22.8 % (13.7 to 31.7 %), NDF 37.1 % (23.7 to 51.0 %) and FDA 20.3 % (11.9 to 29.4 %), suggest better digestibility and efficiency for use in livestock as a supplement⁵. On the other hand, the effect of the age of regrowth or state of maturity of the forage observed in *E. variegata*, caused a decrease of 28.0 to 17.0 % in protein quality²⁸, and could also be considered as a source of nutrients to be used in areas of forage scarcity³¹.

The NDF, FDA and hemicellulose (MEH >16.7 %) of the HP would have values like in other promising forage species (23.6 to 48.5 %, 15.4 to 32.1 % and 8.2 to 32.0 % respectively), which would indicate that their use would depend on the type of animal species³² and values higher than 14.0 % of EMH, such as *Leucaena* leaf meal (EMH 16.0 %) with a substitution level of 32.3 % in the guinea pig diet³³, would guarantee benefits in feed consumption and productive parameters (earliness and profit weight), and therefore an improvement in productivity and guinea pig breeding³⁴.

The regrowth ages with HP had similar effects on CDPT, CDEE, CDCT and ED, moreover, these values reached an ideal digestibility with respect to the harvest carried out at 6 months in *E. poeppigiana*³⁵. On the other hand, the similarity in the behaviour of CDPT (62.1 %) observed at 4 months with respect to alfalfa (PT 62.8 %), suggests an optimal nutritional quality³⁶. Nutrient digestibility is associated with high CP (> 21.8 %), fat (> 6.1 %) and lower fibre (NDF 27.3 % and FDA 16.2 %)³⁷.

Fibre (> to 24.0 %) in HP would probably affect CD, as fibre would seem to increase the rate of passage and cause a decrease in nutrient digestibility³⁵. It would possibly not lead to the development of improved intestinal villus length and width and, therefore, there would be no production of the necessary fatty acids that would affect the luminal environment and its direct action on the intestinal epithelium³⁸.

Another factor would be the age of regrowth: the greater the maturity of the plant, the lower the digestibility of DM, CP and NDF of the HP, the slower the digestion, which would induce food stasis in guinea pigs³⁹, possibly due to the length of the small intestine and the volume of the colon, which represent 55.0 and 37.0 % respectively⁴⁰, furthermore, the greatest retention in the digestion process is observed in the caecum, which represents 60.0 % of the retention time⁴¹.

The DE in the HP would be positively correlated with the TP content, which is observed at 4 months of regrowth age and negatively correlated with the fibre content, which decreases in the other regrowth's, which would indicate that energy would be available by increasing the protein content of the guinea pig diet⁴². The DA of BS would be around 40.75% and

when compared to traditional guinea pig ingredients or inputs the DE is below 2.8 Mcal kg⁻¹ DM⁴³.

HP could be considered as a protein ingredient for guinea pig feed, possibly due to the residence time that would increase digestion in the gastrointestinal tract, due to the contact with the intestinal villi⁴⁴. In addition, due to its remarkable level of fibre, which would be partially or fully fermented from the caecum to the mid-colon, this behaviour would improve nitrogen retention at the caecal level⁴⁵.

The use of non-conventional guinea pig feeds, such as fresh forage, pelleted or extruded, in different feeding systems, would probably improve productive characteristics, such as weight gain and feed conversion⁴⁶, would not significantly affect feed intake and would increase the proportion of fat in the carcasses⁴⁷.

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Conflicts of interest

No conflict of interest.

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Ethical considerations

The study was approved by the Ethics Committee of the Faculty of Veterinary Medicine and Zootechnics of the Micaela Bastidas National University of Apurímac, and the guidelines established by this Committee were followed.

Authors' contribution to the article

Cárdenas-Villanueva Ludwing Angel, experimental execution and sample collection, results supervision, drafting and reviewing the final document for publication. *Ramos-Zuñiga Ruth*, experimental execution, project administration, information search, writing and preparing the original draft.

Limitations in the research

There were no limitations in this research.

Access to data

The data and information from this research are presented in the article.

Permissions for publication

Not applicable.

Cited literature

1. Martin B, Coronel A, Sacido M. *Medicago sativa* en la región centro-este de Argentina. Ocho lustros de historia. UNR Journal 2019;12(1):1-15.
2. Hernández-Espinoza DF, Lagunes-Espinoza L del C, López-Herrera MA, Ramos-Juárez JA, González-Garduño R, Oliva-Hernández J. Edad de rebrote de *Erythrina americana* Miller y concentración de compuestos fenólicos en el follaje. Madera Bosques 2020;26(1):e2611826. DOI: <https://doi.org/10.21829/myb.2020.2611826>
3. Oliva-Hernández J, López-Herrera MA, Castillo-Linares EB. Chemical composition and foliage production of *Erythrina americana* (fabaceae) in living fences during two climatic seasons. Rev

- Biol Trop 2021;69(1):90-101. DOI: <https://doi.org/10.15517/rbt.v69i1.41822>
4. Montero-Durán E, Rojas-Bourrillon A, López-Herrera M. Sustitución de *Cratylia argentea* y *Erythrina poeppigiana* por guineo cuadrado en ensilados. Nutr Anim Trop 2021;15(2):123-46. DOI: <https://doi.org/10.15517/nat.v15i2.48818>
 5. Alcívar Acosta EH, Fernández Roma Y, Vivas WF, Cusme Rivas KE, Verduga López CD, Heredia Mendoza JD. Evaluación del potencial nutricional de especies arbustivas tropicales para la alimentación de cerdos de traspatio. Cienc Tecnol Agropecu 2023;24(3):e2991. DOI: https://doi.org/10.21930/rcta.vol24_num3_art:2991
 6. Instituto Nacional de Estadística e Informática, editores. IV Censo Nacional Agropecuario 2012 [Internet]. Lima: Instituto Nacional de Estadística e Informática; 2012 [citado 02 de mayo de 2024]. 34 p. Recuperado a partir de: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1057/libro.pdf
 7. Instituto Nacional de Estadística e Informática, editores. Encuesta Nacional Agropecuaria 2017. Principales resultados, pequeñas, medianas y grandes unidades agropecuarias [Internet]. Lima: Instituto Nacional de Estadística e Informática; 2018 [citado 02 de abril de 2024]. 123 p. Recuperado a partir de: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1593/libro.pdf
 8. Paredes M, Cerquin M. Efectos de la suplementación de treonina sobre el rendimiento productivo, carcasa y pesos de órganos de cuyes de engorde con alimentación mixta. Rev Investig Vet Peru 2021;32(6):e21702. DOI: <https://doi.org/10.15381/rivep.v32i6.21701>
 9. Trejo-Sánchez F, Mendoza-Martínez G, Plata-Pérez F, Martínez-García J, Villarreal-Espino-Barros O. Crecimiento de cuyes (*Cavia porcellus*) con alimento para conejos y suplementación de vitamina C. Rev MVZ Cordoba. 2019;24(3):7286-90. DOI: <https://doi.org/10.21897/rmvz.1384>
 10. Ortiz-Oblitas P, Florián-Alcántara A, Estela-Manrique J, Rivera-Jacinto M, Hobán-Vergara C, Murga-Moreno C. Caracterización de la crianza de cuyes en tres provincias de la Región Cajamarca, Perú. Rev Investig Vet Peru 2021;32(2):e20019. DOI: <http://dx.doi.org/10.15381/rivep.v32i2.20019>
 11. Meza CJ, Cabrera RP, Morán JJ, Cabrera CA, Miele EM, Meza GA. Profitability and production of guinea pigs fed with forage shrubs tropical in rural area of Quevedo, Ecuador. Cienc y Tecnol 2018;11(2):1-7. DOI: <https://doi.org/10.18779/cyt.v11i2.255>
 12. Cárdenas-Villanueva LA, Ramos-Zuñiga R, Huamán-Gamarra JL, Ramirez Mena E. Effect of the inclusion of pisonay meal (*Erythrina edulis*) of three regrowth ages on the productive characteristics in guinea pigs (*Cavia porcellus*). Rev Investig Vet Peru 2021;32(6):e21702. DOI: <https://doi.org/10.15381/rivep.v32i6.21702>
 13. Nuncio-Ochoa MGJ, Olivera Oliveira AF, Gómez Ramos B, Trujillo Pahua V, Diaz Maldonado IJ, Oviedo Boyso J, et al. Adaptación de leguminosas arbóreas en un sistema silvopastoril para ovinos en clima templado. Rev ESPAMCiencia 2014;15(2):7-15. DOI: https://doi.org/10.51260/revista_espamciencia.v15i2.482
 14. De Cuyper A, Winkler DE, Tütken T, Bosch G, Hummel J, Kreuzer M, et al. Digestion of bamboo compared to grass and lucerne in a small hindgut fermenting herbivore, the guinea pig (*Cavia porcellus*). J Exp Zool A Ecol Integr Physiol 2022; 337(2):128-40. DOI: <https://doi.org/10.1002/jez.2538>
 15. Meza Bone GA, Gutiérrez Sevillano CF, Meza Bone CJ, Cabanilla Campos MG, Vivas Aturo

- WF, Apolo Bosquez JA. Valor biológico de especies arbustivas y arbóreas en el litoral ecuatoriano. *Ciencia y Tecnología* 2023;16(1):24-8. DOI: <https://doi.org/10.18779/cyt.v16i1.690>
16. Choque Durand H, Huaita Patiño A, Cárdenas Villanueva LA, Ramos Zuñiga R. Effect of regrowth age the ruminal degradation of pisonay (*Erythrina* sp) in Andean valley of Abancay. *J High Andean Res* 2018;20(2):189-202. DOI: <http://dx.doi.org/10.18271/ria.2018.363>
17. Cárdenas-Villanueva LÁ, Sarmiento-Casavilca VH, Ramos-Zuniga R. Productive and technological characteristics into guinea pig meat (*Cavia porcellus*) using pisonay based-diets (*Erythrina* sp). *J High Andean Res* 2018;20(4):451-60. DOI: <http://dx.doi.org/10.18271/ria.2018.422>
18. Association of Official Analytical Chemists. Official methods for analysis of the AOAC. Twenty-one Edit. Arlington Virginia, USA: Association of Official Analytical Chemists, Inc; 2019.
19. Van Soest PV, Robertson JB, Lewis BA. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *J Dairy Sci* 1991;74(10):3583-97. DOI: [http://doi.org/10.3168/jds.S0022-0302\(91\)78551-2](http://doi.org/10.3168/jds.S0022-0302(91)78551-2)
20. Mertens DR. Creating a system for meeting the fiber requirements of dairy cows. *J Dairy Sci* 1997;80(7):1463-81. DOI: [http://doi.org/10.3168/jds.S0022-0302\(97\)76075-2](http://doi.org/10.3168/jds.S0022-0302(97)76075-2)
21. Nehring K, Haenlein GFW. Feed evaluation and ration calculation based on net energy. *J Anim Sci* 1973;36(5):949-64. DOI: <http://doi.org/10.2527/jas1973.365949x>
22. Paredes M, Goicochea E. Efecto de cinco dietas con diferentes proporciones de fibra detergente neutro y almidón en el rendimiento productivo, comportamiento ingestivo y peso de órganos digestivos del cuy (*Cavia porcellus*). *Rev Investig Vet Peru* 2021;32(1):e19495. DOI: <http://dx.doi.org/10.15381/rivep.v32i1.19495>
23. Cuibin R, Zea O, Palacios G, Norabuena E, Collazos L, Sotelo A. Determinación de la digestibilidad y energía digestible de la harina de kudzu (*Pueraria phaseoloides*) en el cuy (*Cavia porcellus*). *Rev Investig Vet Peru* 2020;32(4):e19020. DOI: <http://dx.doi.org/10.15381/rivep.v31i4.19020>
24. Castro-Bedriñana J, Chirinos-Peinado D. Nutritional value of some raw materials for guinea pigs (*Cavia porcellus*) feeding. *Transl Anim Sci* 2021; 5(2):1-11. DOI: <http://doi.org/10.1093/tas/txab019>
25. Tijani LA, Akanji AM, Agbalaya K, Onigemo M. Comparative effects of graded levels of moringa leaf meal on haematological and serum biochemical profile of broiler chickens. *J Agric Sci* 2016; 11(3):137-46. DOI: <http://dx.doi.org/10.4038/jas.v11i3.8167>
26. Ascencio-Rojas L, Valles-de la Mora B, Castillo-Gallegos E, Ibrahim M. In situ ruminal degradation and effective degradation of foliage from six tree species during dry and rainy seasons in Veracruz, Mexico. *Agrofor Syst* 2019;93(1):123-33. DOI: <https://doi.org/10.1007/s10457-018-0184-z>
27. Rodríguez R, González N, Alonso J, Domínguez M, Sarduy L. Valor nutritivo de harinas de follaje de cuatro especies arbóreas tropicales para rumiantes. *Revista Cubana de Ciencia Agrícola* 2014;48(4):371-8.
28. Verdecia Acosta DM, Herrera García RS, Ramírez de la Ribera JL, Acosta IL, Bodas Rodríguez R, Sonia Andrés L, et al. Caracterización bromatológica de seis especies forrajeras en el Valle del Cauto, Cuba. *Av en Investig Agropecu* 2014;18 (3):75-90.

29. Régnier C, Bocage B, Archimède H, Noblet J, Renaudeau D. Digestive utilization of tropical foliage of cassava, sweet potatoes, wild cocoyam and erythrina in Creole growing pigs. *Anim Feed Sci Technol* 2013;180(1-4):44-54. DOI: <http://dx.doi.org/10.1016/j.anifeedsci.2012.12.007>
30. Larbi A, Kurdi OI, Said AN, Hanson J. Classification of *Erythrina* provenances by rumen degradation characteristics of dry matter and nitrogen. *Agrofor Syst* 1996;33(2):153-63. DOI: <https://doi.org/10.1007/BF00213647>
31. Mubeena P, Thomas UC, Surendran D. Nutritional evaluation of predominant tree fodders and shrubs of Southern Kerala as a quality livestock feed. *Agric Sci Dig* 2022;42(4):454-8. DOI: <https://doi.org/10.18805/ag.D-5388>
32. Ramos L, Apráez JE, Cortes KS, Apráez JJ. Nutritional, antinutritional and phenological characterization of promising forage species for animal feeding in a cold tropical zone. *Rev Cienc Agr* 2021;38(1):86-96. DOI: <https://doi.org/10.22267/rcia.213801.152>
33. Alagón G, Tupayachi G, Villacorta W, Taco C, Jancco M, Zuniga E, et al. Nutritive value of some concentrate feedstuffs for guinea pigs (*Cavia porcellus*). *Animals (Basel)*. 2024;14(21):3142. DOI: <https://doi.org/10.3390/ani14213142>
34. Kampemba FM, Tshibangu IM, Nyongombe NU, Hornick JL. Palatability of nine fodders species used by guinea pigs (*Cavia porcellus*). *Trop Anim Health Prod* 2017;49(8):1733-9. DOI: <https://doi.org/10.1007/s11250-017-1386-5>
35. Sotelo A, Contreras C, Norabuena E, Castañeda R, van Heurck M, Bullón L. Digestibility and digestible energy of five tropical forage tree legumes. *Rev Soc Quím Peru* 2016;82(3):306-14. DOI: <https://doi.org/10.37761/rsqp.v82i3.84>
36. López S, Guevara H, Duchi N, Moreno G. Evaluation of two “in vitro” digestibility tests with the “in vivo” test of alfalfa (*Medicago sativa*) in guinea pig (*Cavia porcellus*) feeding. *Eur Sci J* 2018;14(6):399-404. DOI: <http://dx.doi.org/10.19044/esj.2018.v14n6p399>
37. Chillpa-Sencia C, Moscoso Muñoz JE, Chino-Velasquez LB, Molina-Botero IC, Gómez Quispe OE, Arjona-Smith M. Digestible energy and nutrient digestibility of full-fat soybean meal in adult and growing guinea pigs. *Rev Fac Agron* 2024;41(4):e244135. DOI: [https://doi.org/10.47280/RevFacAgron\(LUZ\).v41.n4.04](https://doi.org/10.47280/RevFacAgron(LUZ).v41.n4.04)
38. Carcelén Cáceres FD, San Martín Howard F, Ara Gómez M, Bezada Quintana S, Asencios Méndez A, Ruiz García L, Sandoval Monzón R, et al. Inclusion of different levels of inulin on productive parameters and intestinal morphology in fattening guinea pigs (*Cavia porcellus*). *Ciencia Rural* 2021;51(11):e20200961. DOI: <http://doi.org/10.1590/0103-8478cr20200961>
39. Fuss S. Physiologie et pathologie digestives du cobaye domestique: *Cavia porcellus*. [these doctor]. [Toulouse]: Université de Toulouse; 2002 [cité le 26 mai 2024]. Récupéré de: <https://dumas.ccsd.cnrs.fr/dumas-04652413v1>
40. Merchant HA, McConnell EL, Liu F, Ramaswamy C, Kulkarni R, Basit AW, et al. Assessment of gastrointestinal pH, fluid and lymphoid tissue in the guinea pig, rabbit and pig, and implications for their use in drug development. *Eur J Pharm Sci* 2011;42(1-2):3-10. DOI: <http://doi.org/10.1016/j.ejps.2010.09.019>
41. Sakaguchi E, Heller R, Becker G, Engelhardt W. Retention of digesta in the gastrointestinal tract of the guinea pig. *J Anim Physiol Anim Nutr* 1986;55(1-5):44-50. DOI: <http://doi.org/10.1111/j.1439-0396.1986.tb00699.x>
42. Castro-Bedriñana J, Chirinos-Peinado D, Quijada-Caro E. Digestible and metabolizable energy prediction models in guinea pig feedstuffs. *J Appl*

- Anim Res 2022;50(1):355-62. DOI: <https://doi.org/10.1080/09712119.2022.2079647>
43. Vela-Román L, Césare-Coral M, Norabuena-Meza E, Valderrama Rojas MT, Paitan-Anticona E, Airahuacho-Bautista F, et al. Digestibility and estimation of digestible energy of palm kernel (*Elaeis guineensis*) cake in guinea pigs (*Cavia porcellus*). Livest Res Rural Dev [Internet]. 2024 [cited May 5, 2024];36(2):12. Retrieved from: <https://www.lrrd.org/lrrd36/2/3612fair.html>
44. Sotelo A, Valenzuela R, Césare MF, Alegría C, Norabuena E, Gonzáles T, et al. Determinación de la digestibilidad y energía digestible del forraje seco de mucuna (*Mucuna pruriens*) en cuyes. Rev Investig Vet Peru 2020;31(1):e17537. DOI: <https://doi.org/10.15381/rivep.v31i1.17537>
45. Kawasaki K, Min X, Sakaguchi E. Effect of fructo-oligosaccharides on nutrient digestibility and digesta retention time in adult guinea pigs. J Anim Sci 2018;89(3):547-51. DOI: <https://doi.org/10.1111/asj.12957>
46. Cotrina Escobal AR, Crispín Martel KM, Alejos Patiño ÍW, Florida Rofner N. Obtención de alimento balanceado extruido con cáscara de papa (*Solanum tuberosum*) para engorde de cuyes (*Cavia porcellus*). Livest Res Rural Dev [Internet]. 2020 [cited Jun 15, 2022];32(1):19. Retrieved from: <http://www.lrrd.org/lrrd32/1/nelin32019.html>
47. Acuña-Beraun SR, Párraga-Melgarejo N, Álvarez-Tolentino D. Efecto de la suplementación con harina de mashua (*Tropaeolum tuberosum*) y tarwi (*Lupinus mutabilis*) sobre la respuesta productiva y composición nutricional de cuyes (*Cavia porcellus*). Rev Investig Vet Peru 2021;32(2):e18430. DOI: <http://dx.doi.org/10.15381/rivep.v32i2.18430>

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