Agroind. sci. 13(3): 149-155 (2023)

Agroindustrial Science

Website: http://revistas.unitru.edu.pe/index.php/agroindscience

Escuela de Ingeniería Agroindustrial

Universidad Nacional de Trujillo

Nutritional assessment and use of rice polish in feeding guinea pigs (*Cavia porcellus*)

Evaluación nutricional y uso del polvillo de arroz en la alimentación de cuyes (*Cavia porcellus*)

José Víctor Ruiz Ccancce[1, 3, 4]; Liz Beatriz Chino-Velasquez[2, 4, *]; Medardo Antonio Díaz Céspedes[3, 4]; Juan Elmer Moscoso-Muñoz[2, 4]; Víctor Hidalgo Lozano[4]

[1] Facultad de Ingeniería Agraria, Universidad Católica Sedes Sapientiae, Esq. Constelaciones y Sol de Oro s/n Urb. Sol de Oro. Los Olivos, Lima, Perú.
[2] Facultad de Agronomía y Zootecnia, Universidad Nacional de San Antonio Abad del Cusco, Av. Cultura S/N, San Jerónimo, Cusco, Perú.
[3] Facultad de Zootecnia, Universidad Nacional Agraria de la Selva. Car.Central km 1.21, Tingo María, Perú.
[4] Escuela de Posgrado, Universidad Nacional Agraria la Molina, Av. La Molina s/n, La Molina, Lima, Perú.

ORCID de los autores
J. V. Ruíz Ccancce: https://orcid.org/0000-0002-2804-6233
L. B. Chino-Velasquez: https://orcid.org/0000-0002-6322-7371
M. A. Diaz Céspedes: https://orcid.org/0000-0003-0134-8239
J. E. Moscoso-Muñoz: https://orcid.org/0000-0001-5884-9718
V. Hidalgo Lozano: https://orcid.org/0000-0003-4221-7438

ABSTRACT

Two studies were carried out with the aim of determining the digestible energy and the digestibility coefficient of the dry matter and protein of the rice polish; and assess the effect of five levels of rice polish (*Oryza sativa*) to replace wheat bran in diets for growing guinea pigs (*Cavia porcellus*) on productive parameters. In Study I, they were used 12 types I male guinea pigs with an average live weight of 875 g, the digestibility coefficients and digestible energy of rice polish were determined by the indirect method, with the total collection technique. The digestibility coefficient of dry matter was 80.33%, protein 75.51%, energy 78.06% and the digestible energy of rice polish was 3.77 Mcal/kg DM. In Study II, 80 type I improved male guinea pigs were used, of 14+2 days of age and average weight of 441 g, to evaluate the effect of five levels of rice polish: 0%, 4.5%, 7.5%, 15% and 30% in replacement of wheat bran, in 49-day growth diets. As a result, it was observed that there is no significant difference for weight gain, feed intake, feed conversion and carcass yield by replacing wheat bran with rice polish. The inclusion of rice polish at levels greater than 7.5 % affects the productive response in guinea pigs.

Keywords: *Oryza sativa*; digestible energy; digestibility; body weight gain; carcass yield.

RESUMEN

Se realizaron dos estudios con el objetivo de determinar la energía digestible y el coeficiente de digestibilidad de la materia seca y proteína del pulimento de arroz; y evaluar el efecto de cinco niveles de polvillo de arroz (*Oryza sativa*) para reemplazar el salvado de trigo en dietas para cuyes en crecimiento (*Cavia porcellus*) sobre parámetros productivos. En el estudio I se utilizaron 12 cuyes machos tipo I con un peso vivo promedio de 875 g, se determinaron los coeficientes de digestibilidad y energía digestible del polvillo de arroz por el método indirecto, con la técnica de recolección total. El coeficiente de digestibilidad de la materia seca fue 80,33%, proteína 75,51%, energía 78,06% y la energía digestible del polvillo de arroz fue 3,77 Mcal/kg MS. En el estudio II se utilizaron 80 cuyes machos mejorados tipo I, de 14+2 días de edad y peso promedio de 441 g, para evaluar el efecto de cinco niveles de pulimento de arroz: 0%, 4,5%, 7,5%, 15% y 30% en sustitución del salvado de trigo, en dietas de crecimiento de 49 días. Como resultado, se observó que no hay diferencias significativas en el aumento de peso, el consumo de alimento, la conversión alimenticia y el rendimiento de carcasa al reemplazar el salvado de trigo con polvillo de arroz. La inclusión de pulimento de arroz en niveles superiores al 7,5% afecta la respuesta productiva en cuyes.

Palabras clave: *Oryza sativa*; energía digestible; digestibilidad; ganancia de peso; rendimiento de carcasa.

Recibido 10 noviembre 2023
Aceptado 27 diciembre 2023

* Autor correspondiente: liz.chino@unsaac.edu.pe (L. B. Chino-Velasquez)
DOI: http://doi.org/10.17268/agroind.sci.2023.03.05

1. Introduction

Rice is the main cereal in human nutrition and one of the most widespread crops in the world, it represents the main staple food for half of the world's population, mainly in developing countries (Reddy et al., 2017; Chaudhari et al., 2018; Carcea, 2021). In Peru, rice production is the first important agricultural crop due to its contribution to the generation of the gross value of agricultural production (MIDAGRI, 2022), with the Peruvian coast concentrating the highest production (60%) and in second place the high jungle. Between January and July 2022, a production of 2,574 million tons was recorded (MIDAGRI, 2022). The most important by-product of the rice industry is rice polish, causing a high availability of this by-product, for its use in animal feed (Gul et al., 2015).

Rice polish has high nutritional value for feeding birds, pigs and ruminants (Olomonchi et al., 2018), it is also known as polishing, semolina, rice flour or bran (Reddy et al., 2017). This by-product is obtained from the structures that are removed from the caryopsis at the time of husking and piling the rice grain and is made up of the integuments, endosperm, the embryo and part of the sub-aleuronat layer of the starchy endosperm (Gul et al., 2015; Loya-Olguin et al., 2020). The polish represents about 10% of the whole grain of rice, its chemical composition and nutritional value vary depending on the efficiency of polishing processing. In addition, it provides a high oil content (13% to 21%) rich in essential fatty acids. It is also a source of essential and non-essential amino acids, vitamins (thiamine, niacin, vitamin E), minerals (iron, manganese and zinc), dietary fiber and bioactive components (NRC, 1994; Fernando, 2013; Paiva et al., 2014; Gul et al., 2015; Saleh et al., 2019).

With all the benefits reported, the use of this by-product could be a good alternative in guinea pig feeding; since they are non-ruminant herbivorous species and therefore perform post-gastric fermentation (alloenzymatic) with a great capacity for forage consumption because their gastro-intestinal tract is specialized to digest fiber (DeCubellis and Graham, 2013; Kohles, 2014). Likewise, there is a bacterial flora that produces rapid fermentation of fibrous food (Kohles, 2014; Raja et al., 2020).

On the other hand, guinea pigs tend to consume greater amount of food than rabbits, and have less selectivity, additionally showing greater capacity to digest fibrous food and dry matter than rabbits, hamsters and rats (Sakaguchi & Ohmura, 1992). Studies carried out in guinea pigs reported digestibility coefficients for dry matter of corn germ, hominy feed and wheat by-product of 79.0%, 81.2% and 65.3%, respectively, digestible energy of 4189, 4372 and 2801 kcal/kg of dry matter, respectively (Hidalgo & Valerio, 2020). This high digestibility could be due to the high content of easily digestible soluble carbohydrates (69.9%) and the low fiber content (3.2%) of these by-products. Likewise, Farro (2012) reported the digestibility coefficient of rice polish of 51.8%. Regarding performance, Lozada et al. (2013) observed that supplementation with barley and sunflower grains to guinea pigs fed with only alfalfa reported higher weight gain and feed conversion ($p < 0.05$) compared to the control (alfalfa only).

Based on this, the present study aimed to determine the digestible energy and the digestibility coefficient of the dry matter and protein of rice polish; and assess the effect of five levels of rice polish (*Oryza sativa*) to replace wheat bran in diets for growing guinea pigs (*Cavia porcellus*) on productive parameters.

2. Methodology

Study I

This study was carried out in the facilities of the Biological Evaluation Laboratory (biotery) and in the Food Nutritional Evaluation Laboratory of the Faculty of Zootechnics of the La Molina National Agrarian University (UNALM). Twelve improved male type I guinea pigs were used, with seven weeks old with an average weight of 875 g, randomly distributed in 12 individual metabolic cages with a metal structure (50 x 50 x 55 cm in length, width and height, respectively) with mesh floor, built-in feeders and drinkers. For the collection of feces and urine, there was a funnel-shaped tray-type device located in the lower part of the cage, which allowed feces to be separated from urine.

The peroxide index (1.09 meq/kg) was carried out with the purpose of carrying out a preliminary consumption test to establish the level of acceptance of the mixtures (70:30, 60:40 and 50:50% of rice polish and wheat bran, respectively), establishing the best proportion of 50:50% weight/weight ratio. The adaptation period was eight days, where consumption was recorded. The experimental period lasted seven days, food consumption and total collection of feces were recorded daily. Fresh and clean water was supplied at libitum, adding vitamin C (2.5 drops equivalent to 20 mg of vitamin C/guinea pig/day).

The feces were weighed every 24 hours, being stored and frozen at -20 °C. A representative sample of rice polish, wheat bran, the experimental mixture (50% rice polish + 50% wheat bran) and frozen feces samples were dried in a forced convection oven at 60 °C for 48 hours and ground in a Willey type mill (1 mm). Subsequently, the proximal chemical analysis of the food and feces samples was carried out, using the procedures established by the AOAC (2007). Humidity was determined with the method AOAC 930.15; total protein was determined using the method AOAC 984.13 (Kjeldahl method); crude fiber by the method AOAC 962.09; the ether extract by the method AOAC 920.39 (Soxhlet method); the ashes by the method AOAC 942.05 and the gross energy was determined using a Parr Adiabatic Bomb Calorimeter (Moscoso et al., 2020).

To determine the apparent digestibility coefficient (DC) of the wheat by-product (basal diet) and of the mixture, the direct method was used (Díaz et al., 2021): DC (%) = [(IN – EN) / IN] x 100, where IN = Ingested Nutrient; EN = Excreted Nutrient. While the apparent digestibility coefficient of rice polish (DCp) was calculated by the indirect method (Díaz et al. 2021), in which the digestibility coefficient of the wheat bran (B) and the mixture (M): DCp = [(100 x (M – B) /s] + B.

To determine digestible energy, the formula described by Crampton and Harris (1974) was used: DE = GE – (GEF x Qf)/ai), where: DE: Digestible Energy of Food (kcal/kg.), GE: Gross Energy of Food (kcal/kg.), GEF: Gross Energy of Feces (kcal/kg), Qf: Quantity of Feces Produced per day (kg); ai: Amount of Food Ingested per day (kg).

With the average results, the standard deviation (SD) and the coefficient of variability (CV) were calculated for each of the study variables. Table 1 shows the values of the chemical composition of the rice polish, wheat bran and the experimental mixture.

Study II

It was carried out at the Cieneguilla Guinea Pig Farm, Food Plant of the Food Research Program and Food Nutritional Evaluation Laboratory of the Faculty of Zootechnics of the La Molina National Agrarian University (UNALM), 80 improved male type I guinea pigs were used with 14±2 days old, with an average weight of 441 ± 17.76 g, randomly distributed in boxes of four animals each (total 20 boxes or experimental units) with dimensions of 0.90 x 0.45 x 0.60 m in length, width and height, respectively. To avoid moisture problems, ground corn cob (5 cm thick) was used as bedding, each pond had a hopper-type plastic feeder (capacity of 10 kg of food) and automatic drinkers. For the identification of the guinea pigs, aluminum earrings were used in the ear. Live weight and food consumption were recorded using a 5 kg electronic scale, capacity with 1 g sensitivity.

Table 1

Chemical composition of rice polish, wheat bran and the mixture (As Feed and Dry Matter)

Composition, %	Rice polish	Wheat bran	Mix-ture[1]
As Feed			
Humidity	11.02	12.40	12.43
Crude protein	15.31	15.04	15.25
Ether extract	18.21	4.21	11.07
Crude fiber	5.69	5.97	6.25
Ash	9.76	4.67	6.76
Organic matter	90.24	95.33	93.24
Nitrogen free extract	40.01	57.71	48.24
Gross Energy, kcal/kg	4292	4313	4275
Dry Matter			
Crude protein	17.21	17.17	17.41
Ether extract	20.47	4.81	12.64
Crude fiber	6.39	6.82	7.14
Ash	10.97	5.33	7.72
Organic matter	89.03	94.67	92.28
Nitrogen free extract	44.97	65.88	55.09
Gross Energy, kcal/kg	4824	4949	4882

[1]Mixture: 50% wheat bran + 50% rice polish.

The following treatments were evaluated, T-1: control diet (without rice polish), T-2: diet with 4.5 % rice polish, T-3: diet with 7.5 % rice polish, T.4: diet with 15% rice polish and T-5: diet with 30% rice polish. The five experimental diets were formulated according to the requirements of guinea pigs (NRC, 1995). The experimental diets and the chemical composition are presented in tables 2 and 3. The balanced food was supplied at libitum, registering the weight of the food offered and the residual every 24 hours (9:00 to 9:30 am). Additionally, broccoli stubble (*Brassicaceae* sp) was supplied in the post-flowering state (leaves and green stems of the upper third of the plant) previously weighed (20% of live weight) from 09:30 to 10:00 am. The chemical composition of broccoli stubble is shown in Table 4.

The live weight of the guinea pigs was recorded in the morning (08:00 am) before the food supply. The weight gain was determined by the difference between the final weight minus the initial weight and the calculation of the feed conversion was carried out in the same periods, dividing the consumption with the weight gain. At the end of the study, the guinea pigs were benefited, the carcass including the skin, head, legs and viscera (heart, lung, liver, spleen, kidneys) was weighed, which was expressed as a percentage of live weight before benefit to determine carcass yield.

Table 2
Percentage composition of the experimental diets (As Feed)

Ingredient	T-1	T-2	T-3	T-4	T-5
Wheat bran	60.00	55.50	52.50	45.00	30.00
Rice polish	0.00	4.50	7.50	15.00	30.00
Hominy feed	15.65	14.18	13.57	13.07	3.00
Soybean meal	7.05	9.00	9.05	11.80	7.40
Corn gluten	5.07	5.00	4.00	2.00	15.00
Cotton paste	6.00	4.00	5.66	2.90	0.50
Ground alfalfa	3.86	5.40	5.33	7.88	11.62
Calcium carbonate	1.68	1.60	1.60	1.60	1.50
Dicalcium phosphate	0.10	0.22	0.20	0.15	0.20
Common salt	0.30	0.30	0.30	0.30	0.30
Growth promoter	0.10	0.10	0.10	0.10	0.10
Premix[1]	0.10	0.10	0.10	0.10	0.10
Dl-methionine	0.09	0.10	0.09	0.10	0.10
L-lysine	0.00	0.00	0.00	0.00	0.18

[1]Premix (Premix of vitamins and minerals): Vitamin A 9000 UI, Vitamin D3 2000 UI, Vitamin E 16,0 UI, Vitamin K3 2,0 mg, Riboflavin 5,5 mg, Niacin 53,0 mg, Pantothenic acid 11,0 mg, Folic acid 0,1 mg 0.50 g, Biotin 0.30 g, Manganese 112,0 mg 40.00 g, Zinc 100,0 mg, Iron 56,0 mg, Copper 7,0 mg, Iodine 1,0 mg, Selenium 0,1 mg.

Table 3
Chemical composition of the experimental diets (As Feed and Dry Matter)

Composition, %	T-1	T-2	T-3	T-4	T-5
As Feed					
Humidity	9.73	8.88	9.92	10.06	9.18
Crude protein	20.83	20.43	20.39	20.80	21.09
Ether extract	4.95	5.68	6.06	6.53	6.41
Crude fiber	7.95	7.90	9.62	8.04	8.94
Ash	6.33	5.82	7.02	6.76	7.53
Organic matter	93.67	94.18	92.98	93.24	92.47
Nitrogen free extract	59.94	60.16	57.02	57.87	53.83
Dry Matter					
Crude protein	23.08	22.42	22.64	23.13	23.22
Ether extract	5.48	6.23	6.73	7.26	7.06
Crude fiber	8.81	8.67	10.68	8.94	9.84
Ash	7.01	6.39	7.79	7.52	8.29
Organic matter	92.99	93.61	92.21	92.48	91.71
Nitrogen free extract	66.40	66.02	63.30	64.34	59.27

Table 4
Chemical composition of broccoli stubble (*Brassicaceae sp*)

Composition, %	As Feed	Dry Matter
Humidity	85.77	-
Crude protein	4.18	29.37
Ether extract	0.52	3.65
Crude Fiber	2.07	14.55
Ash	1.71	12.02
Organic matter	98.29	87.98
Nitrogen free extract	5.75	40.41

The experimental design used was the Completely Random Design with five treatments (levels of rice polish) and four repetitions (boxes) per treatment. The productive parameters were evaluated: weight gain, feed intake, feed conversion and carcass yield. The normal distribution (Anderson & Darling test) and the homogeneity of the variance (Levene test) were verified. The comparison of means between treatments was performed using Tukey's test at 5% probability. Pearson's correlation and regression analysis were used to establish the effect of rice polish inclusion levels on productive parameters.

3. Results and discussion

Digestibility of dry matter, protein and digestible energy (Study I)

The digestibility values of the rice polish are presented in Table 5, the digestibility of the average dry matter was 80.33%, which is higher than that of wheat bran (68.42%) (Castro-Bedriñana & Chirinos-Peinado, 2021) and the wheat bran (65.3%) reported by Hidalgo and Valerio (2020).

Table 5
Digestibility coefficients of dry matter, protein, energy and digestible energy values of rice polish

Guinea Pig, N°	Digestibility coefficient, %			Digestible energy, Mcal/kg	
	Dry matter	Protein	Energy	Dry matter	As Feed
1	83.08	75.68	82.57	4.010	3.568
2	66.77	62.71	68.10	3.283	2.921
3	81.25	75.40	80.62	3.887	3.459
4	85.93	75.00	82.52	3.986	3.547
5	77.63	79.22	77.76	3.795	3.376
6	87.30	85.06	76.83	3.709	3.300
Average	80.33	75.51	78.06	3.778	3.362
SD[1]	7.48	7.34	5.43	0.32	0.28
CV[1]	9.31	9.72	6.96	8.60	8.46

[1]SD:standard deviation; CV: coefficient of Variability.

Regarding protein, the average digestibility values were 75.51%, which is higher than the protein digestibility of barley grain (63.72%), and wheat bran (70.32%) (Castro-Bedriñana & Chirinos-Peinado, 2021).

The digestibility coefficient of rice polish for energy was 78.06%, this value is similar to that of wheat by-product (78.10%) (Hullar et al., 1992), and lower than barley (80.20%) (Villamide & De Blas, 1991), but higher than that of maize (Villamide & De Blas, 1991; Hullar et al., 1992) and oats (64.90%) (Hullar et al., 1992), the difference could be due to the greater capacity and digestive efficiency of guinea pigs (Sakaguchi et al., 1987¸ Sakaguchi & Ohmura, 1992), since the indicated values correspond to tests carried out in rabbits.

On the other hand, the high digestibility of dry matter compared to other by-products and energy inputs could be due to the fact that rice polish has a low content of crude fiber (5.69%), which is the least digestible fraction, and a high proportion of starch and sugars that it allows the guinea pig to have a good enzymatic and fermentative digestion (Caycedo, 2000), due to their condition as non-ruminant herbivores and therefore they perform post-gastric fermentation (Franz et al., 2010; DeCubellis & Graham, 2013; Kohles, 2014). , showing greater capacity to digest fibrous food and dry matter than other rodents. In addition, the existence of a predominant bacterial flora in the digestive tract favors rapid fermentation of fibrous foods (Kohles, 2014; Raja et al., 2020).

Digestible energy of rice polish

The digestible energy of the rice polish was 3.78 Mcal/kg of dry matter, which represents 78% of utilization (Table 5); this value is higher than common wheat in rabbits (3.70 Mcal/kg) (Hullar et al., 1992), barley grain (3.72 Mcal/kg), corn grain (3.38 Mcal/kg), oats (2.89 Mcal/kg) in rabbits (Villamide and De Blas, 1991), in guinea pigs higher than wheat by-product (2.80 Mcal/kg) but lower than hominy feed (4.37 Mcal/kg) (Hidalgo & Valerio, 2020).

The digestible energy of rice polish found in the study would be due to the nutritional composition of rice polish, which is superior to many by-products commonly used in guinea pig feeding, such as wheat by-product. In addition, the polish is high in energy content (fat), protein and low in fiber, which would favor the digestive processes of the food with a better use of energy. In this regard, Carabaño (1995) and Moscoso-Muñoz et al. (2020) refer that the nutritional value of cereals, like that of any food, depends both on its nutrient content and on the ability of the animal to transform them into body tissues. Likewise, good quality rice polish contains a low percentage of crude fiber and high fat content (Paiva et al., 2014; Gul et al., 2015), which may be the main reason for the high level of digestible energy; Additionally, this result could be due to the fact that the rice polish comes from a series of cell layers that surround the endosperm, rather than as protection, they also participate in the formation of the future rice plant (Gul et al., 2015; Loya-Olguin et al. al., 2020).

For other authors, the chemical composition of rice polish would be directly related to the variety of rice, cultivation conditions, grain size and grain processing for human consumption, also assuming that there is no adulteration of this by-product (Fairulnizal et al., 2015; Reddy et al., 2017; Chaudhari et al., 2018).

Feeding test in the growth stage of guinea pigs (Study II)

The evaluated variables (weight gain, feed intake, feed conversion and carcass yield) did not present significant statistical differences between the levels of inclusion of rice polish in the diet ($p > 0.05$), as observed in Table 6.

Table 6

Weight gain, dry matter intake (g/guinea pig), feed conversion and carcass yield

Parameter	Treatment according to the level of inclusion of RP[1]					p Value
	T-1 (0%[1])	T-2 (4.5%[1])	T-3 (7.5%[1])	T-4 (15%[1])	T-5 (30%[1])	
Concentrated intake, g DM	1546.69	1584.25	1447.81	1456.06	1364.38	0.133
Broccoli consumption, g DM	1062.75**a**	1029.50**e**	1056.25**b**	1051.75**c**	1030.25**d**	0.001
Total intake of DM, g	2609.50	2621.30	2696.00	2711.90	2579.80	0.925
Initial weight, g	450.13	445.05	443.30	434.88	430.80	0.612
Final weight, g	983.88	964.25	979.00	968.13	938.55	0.728
Weight gain, g	533.75	529.38	548.20	523.08	495.25	0.522
feed conversion	4.90	5.00	4.92	5.17	5.22	0.803
Carcass yield, g	749.25	740.75	750.25	735.75	713.00	0.699
Carcass yield, %	76.15	76.82	76.63	76.00	75.97	0.445

[1]RP: Rice polish. a,b,c,d,e: Different letters indicate statistical differences between treatments.

While Lozada et al. (2013) reported significant differences in weight gain and feed conversion in guinea pigs supplemented with barley and sunflower grains. However, in Table 7 is showed that there is a negative correlation between the treatments and the consumption of balanced feed ($R^2 = 0.77$), final weight ($R^2 = 0.81$), weight gain ($R^2 = 0.73$) and carcass yield ($R^2 = 0.89$), which shows that the inclusion of rice polish, especially at levels higher than 15%, reduces feed consumption.

Table 7
Effect of the level of inclusion of rice polish on the response variables

Variable	Model	R^2
Balanced diet consumption, g	Y = - 6.5085 + 1554.00X	0.77
Final weight, g	Y = -1.3510 + 982.16X	0.81
Weight gain, g	Y = -1.4151 + 542.06 X	0.73
Feed conversion	Y = 0.0112 + 4.91X	0.81
Carcass yield, g	Y = -1.211 + 751.61 X	0.89

Y: response variable; X: level of inclusion of rice Polish

4. Conclusions

The apparent digestibility values of rice polish for dry matter, crude protein and energy on average were: 80.33%, 75.71% and 78.06%, respectively. The digestible energy of the rice polish was 3.77 Mcal/kg DM. The inclusion of rice polish higher than 7.5% affected the productive response of the guinea pigs.

References

AOAC - Association of Official Analytical Chemists. (2007). Official Methods of Chemical Analysis. Association of Official Analytical Chemists (18th edition). Gaithersburg, 1018 p.

Caycedo, A. (2000). Experiencias Investigativas en la producción de cuyes. Contribución al desarrollo técnico de la explotación. Universidad de Nariño. Pasto – Colombia. 323 p.

Carabaño, R. (1995). Valor nutritivo de los cereales en conejos. In *Avances en Nutrición y Alimentación Animal: XI Curso de Especialización FEDNA Fundación Española para el Desarrollo de la Nutrición Animal*. 40-46 p.

Castro-Bedriñana, J., & Chirinos-Peinado, D. (2021). Nutritional value of some raw materials for guinea pigs (*Cavia porcellus*) feeding. *Translational Animal Science, 5*(2), txab019. https://doi.org/10.1093/tas/txab019

Carcea, M. (2021). Value of Wholegrain Rice in a Healthy Human Nutrition. *Agriculture 11*(8) 720 p. https://doi.org/10.3390/agriculture11080720

Chaudhari, P. R., Tamrakar, N., Singh, L., Tandon, A., & Sharma, D. (2018). Rice nutritional and medicinal properties: A review article. *Journal of Pharmacognosy and Phytochemistry* 7(2): 150-156.

Crampton, E. W., & Harris, L. E. (1974). Nutrición animal aplicada. Zaragoza, España: Acribia. 756 p.

DeCubellis, J., & Graham, J. (2013). Gastrointestinal Disease in Guinea Pigs and Rabbits. *Veterinary Clinics of North America: Exotic Animal Practice, 16*(2), 421–435. https://doi.org/10.1016/j.cvex.2013.01.002

Díaz Céspedes, M., Rojas Paredes, M. A., Hernández Guevara, J. E., Linares Rivera, J. L., Durand Chávez, L. M., & Moscoso Muñoz, J. E. (2021). Digestibilidad, energía digestible y metabolizable del sacha inchi (*Plukenetia volubilis L*) peletizado y extruido en cuyes (*Cavia porcellus*). *Revista de Investigaciones Veterinarias del Perú, 32*(5), e19654. https://doi.org/10.15381/rivep.v32i5.19654

Farro, G. E. (2012). Digestibilidad aparente, energía digestible y metabolizable de cascarilla de cacao, polvillo de arroz y harina de pituca (*Colocacia esculenta*) en cuyes (*Cavia porcellus*). Tesis de Ingeniero Zootecnista. Univ. Nacional Agraria de la Selva. Tingo María, Perú: 65 p.

Fairulnizal, M. N., Norhayati, M. K., Zaiton, A., Norliza, A. H., Rusidah, S., Aswir, A. R., & Zainuldin, T. M. (2015). Nutrient content in selected commercial rice in Malaysia: An update of Malaysian food composition database. *International Food Research Journal*, 22(2), 768-776.

Fernando, B. (2013). Rice as a Source of Fibre. *Rice Research: Open Access, 1*(2), e101. https://doi.org/10.4172/jrr.1000e101

Franz, R., Kreuzer, M., Hummel, J., Hatt, J.-M., & Clauss, M. (2010). Intake, selection, digesta retention, digestion and gut fill of two coprophageous species, rabbits (*Oryctolagus cuniculus*) and guinea pigs (*Cavia porcellus*), on a hay-only diet. *Journal of Animal Physiology and Animal Nutrition, 95*(5), 564–570. https://doi.org/10.1111/j.1439-0396.2010.01084.x

Gul, K., Yousuf, B., Singh, A. K., Singh, P., & Wani, A. A. (2015). Rice bran: Nutritional values and its emerging potential for development of functional food - A review. *Bioactive Carbohydrates and Dietary Fibre, 6*(1), 24–30. https://doi.org/10.1016/j.bcdf.2015.06.002

Hidalgo, L.V., & Valerio, C.J. (2020). Digestibilidad, energía digestible y metabolizable del gluten de maíz, hominy feed y subproducto de trigo en cuyes (*Cavia porcellus Revista de Investigaciones Veterinarias del Perú, 31*(2), e17816. http://dx.doi.org/10.15381/rivep.v31i2.17816

Hullar, I., Fekete, S., & Gippert, T. (1992). Comparison of Rabbit and Coypu Digestion on the Basis of Digestibility Trials. *Journal of Applied Rabbit Research*, *15*, 995-1007.

Kohles, M. (2014). Gastrointestinal Anatomy and Physiology of Select Exotic Companion Mammals. *Veterinary Clinics of North America: Exotic Animal Practice, 17*(2), 165–178. https://doi.org/10.1016/j.cvex.2014.01.010

Loya-Olguin, J. L., Vega-Granados, E., Gómez-Gurrola, A., Navarrete-Méndez, R., Calvo-Carrillo, C., García-Galicia, I. A., Valdés-García, Y. S., & Sanginés-García, L. (2020). Rumen fermentation and diet degradability in sheep fed sugarcane (*Saccharum officinarum*) silage supplemented with Tithonia diversifolia or alfalfa (*Medicago sativa*) and rice polishing. *Austral journal of veterinary sciences, 52*(2), 55–61. https://doi.org/10.4067/s0719-81322020000200055

Lozada, P. P., Jiménez, A. R., San Martín, H. F., & Huamán, C. R. (2013). Efecto de la inclusión de cebada grano y semilla de girasol en una dieta basada en forraje sobre el momento óptimo de beneficio de cuyes. *Revista de Investigaciones Veterinarias del Perú, 24*(1), 25-31.

MIDAGRI. (2022). Observatorio de Commodities. Arroz. Dirección de Estudios Económicos, Dirección General de Políticas Agrarias. Ministerio de Agricultura. Boletín Trimestral N° 02-2022.

Moscoso-Muñoz, J. E., Gomez-Quispe, O., & Guevara-Carrasco, V. (2020). Contenido de energía metabolizable y energía neta del maíz, subproducto de trigo, harina de soya, harina de pescado y aceite de soya para pollos de carne. *Scientia Agropecuaria, 11*(3), 335-344. http://dx.doi.org/10.17268/sci.agropecu.2020.03.05

National Research Council (NRC). (1994). Nutrient requirements of Poultry. National Academy of Sciences. Ninth Revised Edition. 157 p.

National Research Council (NRC). (1995). Nutrient requirements of laboratory animal. National Academy of Sciences. Fourth revised edition. 96 p.

Olomonchi, E., Akdag, A., y Garipoglu, A.V. (2018). Possibilities of using Bran in Dairy Nutrition. Conference: 4 TH. *International Agriculture Congress*. 5-8

Paiva, F. F., Vanier, N. L., Berrios, J. D. J., Pan, J., Villanova, F. de A., Takeoka, G., & Elias, M. C. (2014). Physicochemical and nutritional properties of pigmented rice subjected to different degrees of milling. *Journal of Food Composition and Analysis*, *35*(1), 10–17. https://doi.org/10.1016/j.jfca.2014.05.003

Raja, K., Ushakumary, S., Ramesh, G., Ramesh, S., & Venkata, G. (2020). Gross anatomical studies on the large intestine in adult guinea pig (*Cavia porcellus*). *Journal of Entomology and Zoology Studies*, *8*(3), 926-929.

Reddy, C. K., Kimi, L., Haripriya, S., & Kang, N. (2017). Effects of Polishing on Proximate Composition, Physico-Chemical Characteristics, Mineral Composition and Antioxidant Properties of Pigmented Rice. *Rice Science*, *24*(5), 241–252). https://doi.org/10.1016/j.rsci.2017.05.002

Sakaguchi, E., Itoh, H., Uchida, S., & Horigome, T. (1987). Comparison of fibre digestion and digesta retention time between rabbits, guinea-pigs, rats and hamsters. *British Journal of Nutrition,* *58*(1), 149–158. https://doi.org/10.1079/bjn19870078