ORIGINAL PAPER

Effect of alfalfa, concentrate and ryegrass diets on guinea pig production variables

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ABSTRACT

The present research evaluates the productive performance of guinea pigs fed with two different feed rations. Three groups of 15 male Peruvian guinea pigs were formed, each with three repetitions of five individuals. The guinea pigs in the control group (T_0) were fed only with alfalfa, the first treatment group was fed with a combination of alfalfa and concentrated feed in a 3:1 ratio, respectively (T_1), and the second experimental group was fed with ryegrass and the same balanced supplement, also in a 3:1 ratio (T_2). At the end of the nine-week study, the average live weights obtained were 917.67 g in T_0, 948.13 g in T_1, and 911.60 g in T_2. The average feed intake based on dry matter per guinea pig/day was increased gradually, with lower quantities for the group of guinea pigs fed only with alfalfa and higher quantities for the group of guinea pigs fed with ryegrass and concentrated feed. The feed conversion was better in T_1 compared to the other two groups ($p = <0.001$). It is concluded that guinea pigs fed with alfalfa and supplemented with concentrated feed show greater weight gain.

Keywords: *Cavia porcellus*, feeding, weight gain, feed conversion, production.

RESUMEN

En esta investigación, se evalúa el desempeño productivo en cuyes alimentados con dos raciones alimenticias distintas. Se formaron tres grupos de 15 cuyes machos de la raza Perú, cada uno con tres repeticiones de cinco individuos. Los cuyes del grupo de control (T_0) fueron alimentados únicamente con alfalfa; el primer grupo de tratamiento, con alfalfa y alimento concentrado en proporciones de 3:1, respectivamente (T_1); y el segundo grupo experimental, con ryegrass y el mismo suplemento balanceado, también en proporción 3:1 (T_2). Al culminar el estudio de nueve semanas, se obtuvieron pesos vivos promedios de 917,67 g en el T_0, 948,13 g en el T_1 y 911,60 g en el T_2. La ingesta media de alimento con base en materia seca por cuy/día fue creciente, con aumentos menores para el grupo de cuyes alimentados únicamente con alfalfa y mayores para el grupo de cuyes alimentados con ryegrass y alimento balanceado. La conversión alimenticia fue mejor en el T_1 en comparación con los otros dos grupos ($p = <0.001$). Se concluye que, los cuyes alimentados con alfalfa y adición de concentrado tienen una mayor ganancia de peso.

Palabras clave: *Cavia porcellus, alimentación, ganancia de peso, conversión alimenticia, producción.*

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INTRODUCTION

The guinea pig (*Cavia porcellus*) is distributed worldwide. Its breeding has generated increasing interest as it has positioned itself as a regular source of high-quality animal protein for domestic consumption. Due to its prolific nature, it contributes to food security and provides a small but frequent economic income to the population in developing countries. Moreover, guinea pigs reproduce in different habitats and adapt to a wide range of climates and diets (Lammers *et al.,* 2009; Sánchez-Macías *et al.,* 2016; Ngoula *et al.,* 2017).

Guinea pig breeding has gained importance because its protein production is possible at a low cost due to its diet based on feed, forages, and vegetable waste from crops and traditional markets (Sánchez-Macías *et al.,* 2018). However, if meat production is to be increased, they can be fed with concentrates and supplements (Sánchez-Macías *et al.,* 2018). Guinea pigs are considered contributors to food security due to their health properties and high content of proteins, B-group vitamins, linoleic and linolenic acids, and low content of saturated fats and cholesterol (Quevedo, 2012; Avilés *et al.,* 2014).

Guinea pigs have a broad capacity to utilize different types of food, making good use of everything-from fiber-rich to protein-rich foods. Despite fiber having lower nutritional value, guinea pigs utilize it better than other monogastric animals due to their functional cecum, resulting in lower utilization of nutrients and metabolizable energy. Additionally, protein intake contributes to greater energy utilization, while including concentrates and other supplements in their diet enhances their nutritional intake (Kouakou *et al.,* 2013; Sánchez-Macías *et al.,* 2018; Castro-Bedriñana and Chirinos-Peinado, 2021).

Traditionally, guinea pigs have been fed with green forage. However, to improve productive variables such as weight gain, feed consumption, feed conversion, etc., various supplements and foods have been used, such as balanced feed with vitamin C (Reynaga *et al.,* 2020), barley flour, and mineral blocks (Quintana *et al.,* 2013). Biological fish silage (Mattos *et al.,* 2003), probiotic mixtures (Cano *et al.,* 2016), and vitamin and mineral mixtures (Paredes and Díaz, 2023) have also been used.

Guinea pig breeding is increasingly widespread in Peru and around the world. It represents an important source of animal protein supply and economic income (Kouakou *et al.,* 2011; Avilés *et al.,* 2014; Ngoula *et al.,* 2017). However, there is still limited information on the effects of different feeds used in their diet. For this reason, the present research was conducted to evaluate the productive variables of feed consumption, weight gain, and feed conversion in Peruvian guinea pigs in the fattening phase fed with two feed rations.

MATERIALS AND METHODS

Study location: The present research was conducted at the guinea pig shed San José (-7.1281072 S, -78.479220 W), located within the district of Los Baños del Inca, Cajamarca (Peru). It is situated at 2749.53 meters above sea level and has a temperate climate, with an average annual temperature of 14.5ºC and a relative humidity of 69.75%.

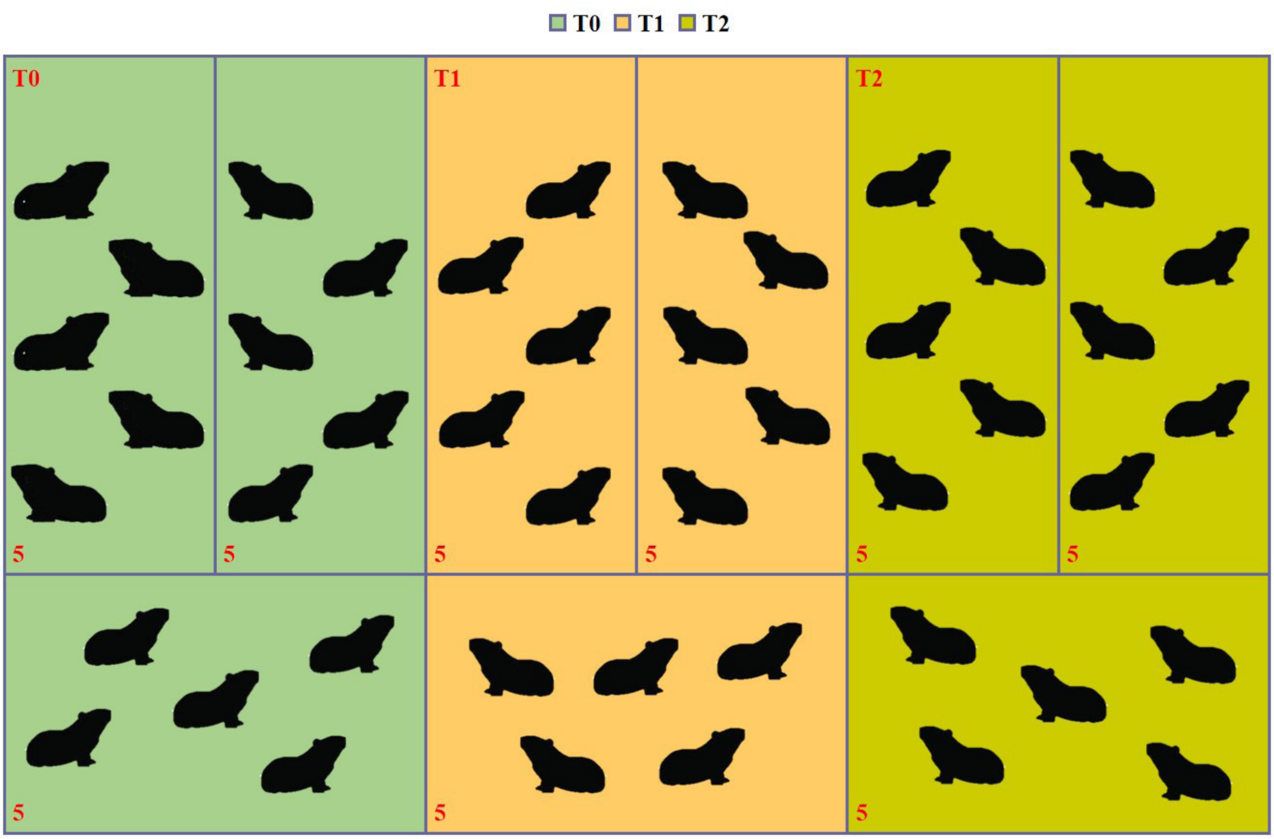

Figure 1. Distribution of guinea pigs in the three groups: control group and two treatment groups.

Experimental design: In this study, a completely randomized design was proposed using forty-five male Peruvian guinea pigs, 21 days old and with similar body condition scores, which were divided into three groups randomly and then each group was randomly assigned one of the three treatments (T_0, T_1, and T_2). Each cage housed 15 animals (of each treatment), divided into three compartments in which 5 guinea pigs were randomly placed, forming three replicates per cage, as shown in figure 1. Each cage was built with galvanized wire mesh and wood (dimensions 3 m long, 0.90 m wide and 0.90 m high).

The guinea pigs in the control group (T_0) were fed only with fresh alfalfa at the flowering phase (10%) (*Medicago sativa*). The guinea pigs in T_1 were fed with fresh alfalfa and commercial concentrate in a 3:1 ratio, and the guinea pigs in T_2 were fed with Cajamarca ecotype Ryegrass (*Lolium multiflorum*) and commercial concentrate in a 3:1 ratio, respectively. The concentrated feed in T_1 and T_2 was given in clay deposits, that is, it was given separately from the forage. The food quantities administered were based on the 30% of their body weight per day. The nutritional composition of the inputs is shown in table 1.

Water was supplied through nipple drinkers. Seven days before the start of the study, all guinea pigs underwent a parasitological examination using the sugar flotation method and natural sedimentation to concentrate the eggs of gastrointestinal and hepatic parasites. The guinea pigs that tested positive for parasite eggs were treated with a formulation based on ivermectin-clorsulon at a dose of 0.2 mg/kg - 2 mg/kg, administered subcutaneously. The study continued once the effectiveness of the antiparasitic treatment was verified through fecal egg counts. For 63 days, a strict health and biosafety program was followed, and the cleaning and collection of manure and food waste were carried out daily. Additionally, the guinea pig housing area floor was periodically disinfected with lime (CaO) every week.

Collection of data: Each guinea pig was weighed at the beginning (IBW) and at the end of the study (FBW) total weight gain, feed intake - FI (difference between the given feed quantity and residue), and feed conversion - FC (Feed intake [DM]/weight gain) were calculated weekly using a digital balance.

Statistical analysis: The data obtained from the productive parameters were subjected to a completely randomized analysis of variance with normally distributed variables (ANOVA). Post hoc, Tukey's Honestly Significant Difference test was applied to determine statistical differences between the treatment means, with a significance level of $p < 0.05$. The analysis of variance for the variables of feed intake and feed conversion ratio was conducted separately for each week.

RESULTS

At the end of the nine-week study, guinea pigs fed with fresh alfalfa plus concentrated feed (T_1) achieved the highest FBW 948.13 g ($p < 0.05$). Guinea pigs fed T_0 and T_2 showed statistically similar FBW (T_0 = 917.67 g and T_2 = 911.6 g, respectively) (figure 2).

Similarly, the guinea pigs in T_1 showed higher weekly and daily weight gains in the ninth week compared to T_0 and T_2 (p = < 0.001) (table 2).

FI and FC were numerically similar during the first two weeks in all three groups. Between the third and eighth weeks, FI and FC of T_0 and T_2 were the most notable differences (p = <0.001), showing the highest FI and FC. However, in the ninth week, FI was again similar between T_0 and T_1 ($p > 0.05$). FC showed a statistical difference between T_0, T_1, and T_2 (p = <0.001). Notably, T_1 exhibited the lowest value of feed conversion (table 2).

DISCUSSION

One of the reasons why guinea pigs fed with T_1 showed higher FBW compared to those fed T_0 and T_2 may be due to the higher protein content of both components when administered together. The results showed that alfalfa contained 24% CP, while the concentrated feed had 18%, and the ryegrass was 13.36% CP.

Although FI and FC showed statistical differences at the beginning and end of the study, these were not numerically considerable. The similarity initially observed could be explained by the fact that the internal organs of the guinea pigs complete their development to become fully functional, enabling them to begin consuming large quantities of high-fiber, low-energy-density feeds (Kholes, 2014). This same pattern of difference persisted throughout the remaining weeks, which could be attributed to the intrinsic requirements of each animal, as not all have the same metabolism, leading some to consume more than others. FI was similar in the final week, possibly due to the guinea pigs completing their growth stage, as they are mature for reproduction by day 50 after birth (Hirakow and Gotoh, 1980). At the end of the study, the guinea pigs were 84 days old.

On the other hand, T_0 and T_2 exhibited higher FI between the third and eighth week, which could be due to increased consumption to acquire the necessary protein levels. The best FC was achieved in the group of guinea pigs fed with fresh alfalfa and concentrated feed (T_1). This outcome might be influenced by specific characteristics of the forage itself, such as lower dry matter percentage and higher protein content in the feed, allow-

Component	Alfalfa	Ryegrass	Concentrate feed
Dry matter (%)	17.00	26.76	87.90
ME (Mcal/kg)	2.36	2.58	2.73
Protein (%)	24.00	13.36	18.00
Crude Fiber (%)	22.3	17.81	7.98
Calcium (%)	2.00	0.73	0.90
Phosphorus (%)	0.35	0.36	0.61

Table 1. Nutritional composition of the feed inputs used in the control group and treated groups of guinea pigs.

ing the guinea pigs to meet their nutritional requirements with lower FI. However, specific studies are needed to evaluate individual ingredients and examine the effects of each component.

Due to the ability of guinea pigs to efficiently utilize fibrous and protein-rich foods, thanks to their functional cecum that optimizes nutrients and energy, especially when supplemented with concentrated feed and other supplements (Kouakou *et al*., 2013; Sánchez-Macías *et al*., 2018; Castro-Bedriñana and Chirinos-Peinado, 2021), the higher protein and metabolizable energy provided by alfalfa and concentrated feed resulted in the best productive variables. Therefore, alfalfa plus concentrated feed could optimize and standardize results, leading to guinea pigs with higher live weights, as the market demands standard-sized and high-quality guinea pigs (Flores-Mancheno *et al*., 2017).

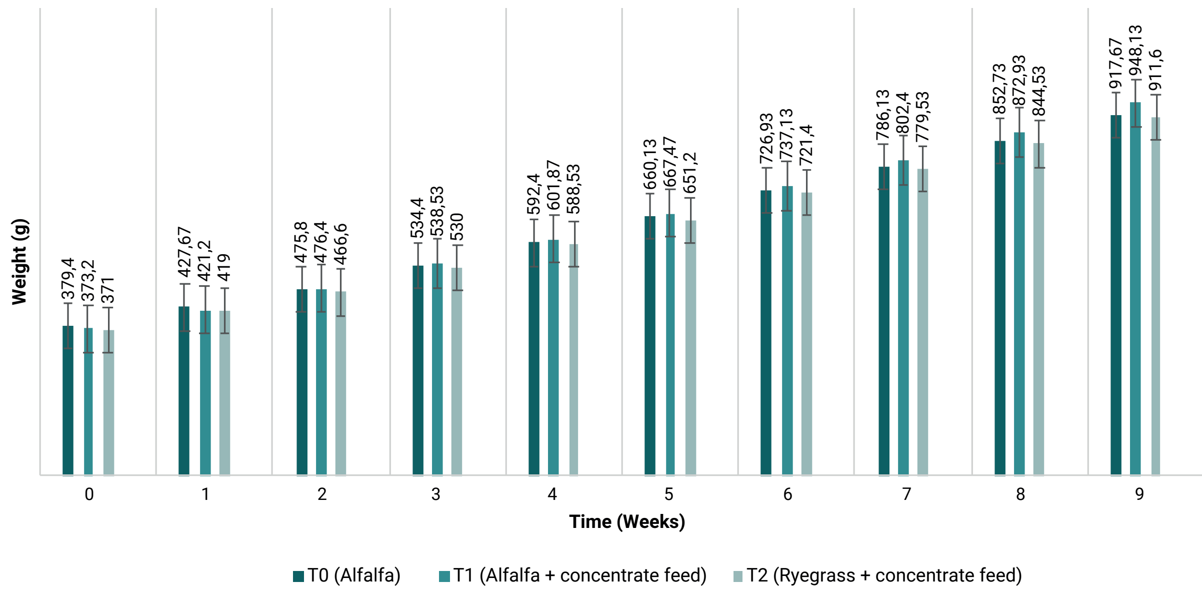

Figure 2. Average live weights of guinea pigs at the end of the nine-week study.

Time	Feed intake in grams (DM)				Feed conversion				Weight gain			
	T_0 (x̄ ± SE)	T_1 (x̄ ± SE)	T_2 (x̄ ± SE)	*P value*	T_0 (x̄ ± SE)	T_1 (x̄ ± SE)	T_2 (x̄ ± SE)	*P value*	T_0 (x̄ ± SE)	T_1 (x̄ ± SE)	T_2 (x̄ ± SE)	*P value*
Week 1	43.20 ± 0.082^{a}	40.00 ± 0.060^{b}	44.00 ± 0.068^{c}	*<0.001*	6.26 ± 0.004^{a}	5.83 ± 0.004^{b}	6.41 ± 0.004^{c}	*<0.001*	48.27 ± 0.004^{a}	48.04 ± 0.005^{b}	47.95 ± 0.005^{c}	*<0.001*
Week 2	44.50 ± 0.049^{a}	43.70 ± 0.058^{b}	45.00 ± 0.019^{c}	*<0.001*	6.47 ± 0.004^{a}	5.55 ± 0.004^{b}	6.62 ± 0.004^{c}	*<0.001*	48.14 ± 0.004^{a}	55.20 ± 0.004^{b}	47.61 ± 0.004^{c}	*<0.001*
Week 3	48.40 ± 0.079^{a}	50.00 ± 0.020^{b}	60.00 ± 0.030^{c}	*<0.001*	5.78 ± 0.003^{a}	5.63 ± 0.002^{b}	6.62 ± 0.003^{c}	*<0.001*	58.60 ± 0.006^{a}	62.13 ± 0.006^{b}	63.40 ± 0.006^{c}	*<0.001*
Week 4	50.80 ± 0.101^{a}	54.00 ± 0.162^{b}	61.00 ± 0.279^{c}	*<0.001*	6.13 ± 0.003^{a}	5.97 ± 0.002^{b}	7.30 ± 0.003^{c}	*<0.001*	58.00 ± 0.006^{a}	63.33 ± 0.006^{b}	58.53 ± 0.006^{c}	*<0.001*
Week 5	59.80 ± 0.081^{a}	62.00 ± 0.228^{b}	65.80 ± 0.048^{c}	*<0.001*	6.18 ± 0.003^{a}	6.62 ± 0.002^{b}	7.35 ± 0.002^{c}	*<0.001*	67.73 ± 0.006^{a}	65.60 ± 0.006^{b}	62.67 ± 0.006^{c}	*<0.001*
Week 6	63.00 ± 0.021^{a}	68.00 ± 0.282^{b}	73.80 ± 0.160^{c}	*<0.001*	6.60 ± 0.002^{a}	6.83 ± 0.002^{b}	7.36 ± 0.002^{c}	*<0.001*	66.80 ± 0.006^{a}	69.67 ± 0.006^{b}	70.20 ± 0.006^{c}	*<0.001*
Week 7	67.00 ± 0.138^{a}	69.00 ± 0.135^{b}	73.00 ± 0.159^{c}	*<0.001*	7.80 ± 0.002^{a}	7.51 ± 0.002^{b}	8.78 ± 0.002^{c}	*<0.001*	59.20 ± 0.006^{a}	65.27 ± 0.006^{b}	58.13 ± 0.006^{c}	*<0.001*
Week 8	76.00 ± 0.087^{a}	76.00 ± 0.094^{a}	82.00 ± 0.066c	*<0.001*	7.99 ± 0.002^{a}	7.54 ± 0.002^{b}	8.83 ± 0.002^{c}	*<0.001*	66.60 ± 0.006^{a}	70.53 ± 0.006^{b}	65.00 ± 0.006^{c}	*<0.001*
Week 9	82.00 ± 0.333^{a}	85.00 ± 0.284^{b}	85.00 ± 0.055^{b}	*<0.001*	8.84 ± 0.002^{a}	7.91 ± 0.002^{b}	8.87 ± 0.002^{c}	*<0.001*	64.93 ± 0.006^{a}	75.20 ± 0.006^{b}	67.07 ± 0.006^{c}	*<0.001*
Final (x̄)	**59.41 ± 1.130^{a}**	**60.87 ± 1.232^{a}**	**65.32 ± 1.190^{b}**	***<0.001***	**6.89 ± 0.085^{a}**	**6.59 ± 0.073^{b}**	**7.57 ± 0.082^{c}**	***<0.001***	**59.81 ± 0.617^{a}**	**63.88 ± 0.669^{b}**	**60.06 ± 0.645^{a}**	***<0.001***

^{abc} Different letters indicate a statistical difference between groups (T0, T1, and T2) within each variable (feed intake, feed conversion, and weight gain) (ANOVA, Tukey, $p < 0.05$ *posthoc*).

SE: Standard error.

Table 2. Feed intake, feed conversion, and weight gain of guinea pigs fed with only alfalfa (T_0), alfalfa plus concentrated feed (T_1), and ryegrass plus concentrated feed (T_2).

Time	Feed intake in grams (DM)			Feed conversion		
	T_0 ($\bar{x}$)	T_1 ($\bar{x}$)	T_2 ($\bar{x}$)	T_0 ($\bar{x}$)	T_1 ($\bar{x}$)	T_2 ($\bar{x}$)
Week 1	43.20^a	40.00^a	44.00^a	6.26^a	5.83^a	6.41^a
Week 2	44.50^a	43.70^a	45.00^a	6.47^a	5.55^a	6.62^a
Week 3	48.40^b	50.00^b	60.00^a	5.78^b	5.63^b	6.62^a
Week 4	50.80^b	54.00^b	61.00^a	6.13^b	5.97^b	7.30^a
Week 5	59.80^b	62.00^b	65.80^a	6.18^b	6.62^b	7.35^a
Week 6	63.00^b	68.00^b	73.80^a	6.60^b	6.83^b	7.36^a
Week 7	67.00^b	69.00^b	73.00^a	7.80^b	7.51^b	8.78^a
Week 8	76.00^b	76.00^b	82.00^a	7.99^b	7.54^b	8.83^a
Week 9	82.00^a	85.00^a	85.00^a	8.84^a	7.91^b	8.87^a
Final ($\bar{x}$)	**59.30**	**60.96**	**65.51**	**6.89**	**6.59**	**7.57**

^{a,b} Different letters in the same row within each variable indicate a statistically significant difference (Tukey, $p < 0.05$).

Table 3. Food consumption and feed conversion of guinea pigs fed with sole alfalfa (T_0), alfalfa plus concentrated feed (T_1), and ryegrass plus concentrated feed (T_2).

The type of feeding also influences the productive variables of guinea pigs. The combination of forage and concentrated feed, as seen in groups T_1 and T_2 in this study, represents a mixed feeding system. In some studies, integrated and mixed feeding systems have shown similar results or no statistical differences (Huamaní *et al*., 2016; Yoplac *et al*., 2017; Choez and Ravillet, 2018). However, in other studies, guinea pigs fed under a mixed system achieved better productive variables, such as higher final weights and daily weight gains, leading to a better carcass performance, albeit with a higher feed consumption (Quintana *et al*., 2013; Reynaga *et al*., 2020).

Although a more efficient feed conversion has been achieved in guinea pigs under an integrated feeding system in some studies (Morales *et al*., 2011; Airahuacho and Vergara, 2017; Reynaga *et al*., 2020), the addition of alfalfa or other green forages is necessary for the proper functioning of the digestive system and to prevent wear of the teeth and malocclusions that could affect feed consumption (Saunders, 2010).

CONCLUSIONS

The administration of alfalfa and concentrated feed showed better performance of guinea pigs compared to those achieved through the administration of only alfalfa and ryegrass supplemented with concentrated feed.

AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of this study, along with the supervision and conduction of the research. Herrera H and Niño J contributed to the validation, data curation, and writing-preparation of original drafts. Vargas-Rocha L and Torrel S collaborated in viewing, writing-reviewing, and editing the manuscript. All authors read and approved the final manuscript.

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DATA AVAILABILITY

All data pertinent to this study are included in this study.

COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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