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Research Article

Effect of Creep Feed Formulated with Palm Kernel Cake and Tropical Forages on Growth Performance of Boer Crossbred Kids

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Abstract | The aim of this study was to examine the potential of creep feed formulated with agro-industrial by-products from the palm oil and rice industries as corn replacers, as well as tropic forages like dwarf Napier grass and *Trichanthera gigantea* for pre-weaning Boer crossbred kids. Proximate analyses were conducted on the feed ingredients and the newly formulated feed before the feeding trial. Twelve (n=12), single-born Boer x Jamnapari crossbred kids, with an average birth weight of 3.25 kg and body condition scoring of 3 to 3.5 were randomly divided into two dietary treatment groups (n=6 per group), each containing 3 males and 3 females. In the first treatment (T1) group, all the kids received only dam's milk from day 1 to day 90 of age, whereas for the second treatment (T2) group, the kids were given formulated creep feed from 14 days old until 90 days old, in addition to the regular suckling. The body weight and daily creep feed intake were calculated to obtain the average daily gain (ADG) and feed conversion ratio (FCR). The result showed that the male kids in the T2 groups showed significantly ($P<0.05$) higher total weight gain (14.50 vs. 11.33 kg) and final weight (19.67 vs. 13.67 kg) at day 90 compared to the full suckling male kids, respectively. Similarly, the female kids in T2 group compared to T1 group showed significantly ($P<0.05$) higher total weight gain (10.17 vs. 7.5 kg) and final weight (15.83 vs. 13.17 kg) at day 90, respectively. The feed conversion ratios for male and female kids of T2 groups were 1.66 and 1.79, respectively with no significant difference ($P\geq0.05$). It is concluded that supplementation of the newly formulated creep feed from 14 days old to the weaning stage enhances the growth performance of Boer cross-bred kids.

Keywords | Creep feed, Palm kernel cake, Dwarf Napier, *Trichanthera gigantea,* Pre-weaning goat, Growth performance

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INTRODUCTION

Creep feed is a supplemental solid feed for suckling kids that is adopted with the aim of accelerating weaning (Hayes *et al*., 2019). Creep feed is usually introduced to kids about 2 weeks of age, and it is expected that kids could consume 200 to 250 g/day from age 20 days through weaning. The creep feed rations must be palatable and contain at least 15% crude protein (CP) (Hayes *et al*., 2019).

Typically, during the initial 3 to 4 weeks, young off spring

primarily depend on their mother's milk as their source of nutrients (Hart and Delaney, 2016; Vickery *et al*., 2023). This phase lasts until the weaning process begins. The weaning phase often leads to a decrease in feed intake and a temporary fasting period in juvenile animals due to the stress associated with the transition (Sayer, 2010). In the case of goats, the weaning stress is prompted by various factors including alterations in their diet, shifting from milk to solid food, environmental changes, and separation from their maternal figure (Hayes *et al*., 2019). These stressors reduce immune function and result in young kids' exposure to high infection rates, especially coccidiosis, because of incomplete rumen development. In order to reduce the weaning stress for the kids, it is recommended to provide some solid feeds as an alternative energy source to the pre-weaning kids, which can help to reduce the neophobia for the weaner diet (Cash *et al*., 2017; Vickery *et al*., 2023). Consequently, this may improve the feed intake and growth of weaned kids. After 3 to 4 weeks, the kids also start to nibble on some high-quality feed which means they would have a chance to compete in the feed intake with their mothers (Pond *et al*., 2005). Thus, creep feed is suggested to be provided before weaning for better growth performance.

However, creep feed comes at a cost (Middelkoop *et al*., 2020). Countries with limited cereal grains in particular maize production for animal feed faced a major hurdle in sustaining a profitable animal farming industry due to the high importation cost of raw ingredients and being heavily dependent only on cereal grains for animal feed production, which is also not sustainable in the long run (Pinotti *et al*., 2021). Hence, it is essential to explore the use of agro-industrial by-products in non-conventional feed production to reduce the reliability maize as an alternative feed for animal farming (Yang *et al*., 2021). Among the agro-industrial by-products available in tropical countries, palm kernel cake (PKC) (Saeed *et al*., 2018), rice bran, and broken rice are feasible to be used as energy source for feed production due to their abundant availability. According to a study by Halim *et al*. (2017), the substitution of 30-50% premium PKC that contains low shell (≤6%), high CP (≥16.5%) and low crude fiber (≤10%) in feed formulation can equate to 25-28% of corn and 2-5% of soybean replacements. Besides that, studies have shown that the inclusion of roughage and tree fodder that is high in protein such as Napier grass (*Pennisetum purpureum*), mulberry, moringa and *Trichanthera gigantea* leaf meal at an optimum amount could improve the growth performance of ruminants (Kandylis *et al*., 2009; Rahman *et al*., 2013; Jack *et al*., 2021).

Nevertheless, there is still a research gap regarding the potential benefits of creep feeding on kids' performance using local agro-industrial by products and tropical forages specifically *T. gigantea*. Thus, the objectives of this research were to evaluate the utilization of local agro-industrial by-products and tropical forage in particular PKC, broken rice, rice bran, soybean waste, Napier grass and *T. gigantea* leaf as an alternative source to formulate creep feed and determine the intake and growth performance of pre-weaning kids upon feeding trial.

MATERIALS AND METHODS

Experimental site and ethical approval

This study was carried out at the goat farm (4°20'36"N, 101°8'12"E) in the Agriculture Park of University Tunku Abdul Rahman (UTAR), Kampar Campus, Perak, Malaysia. The experiment has been approved by UTAR Scientific and Ethical Review Committee (Approval no: U/SERC/88/2022).

Experimental design

In this study a total of 12 dam-kid pairs of Boer crossbred (Boer × Jamnapari) goats were used as experimental animals. All the selected kids were from a single birth. The 12 dam-kid pairs (live weight; 3.0-3.5 kg and body condition score (BCS); 3 to 3.5) were randomly assigned to one of two treatment groups with consideration of assigning the sex (male or female) of offspring uniformly for the control (T1) and treatment (T2) groups. The T1 group is referred to as fully suckling for 12 weeks post-parturition, while the T2 group, kids were provided with newly formulated creep feed from 14 days-old onwards to 12 weeks post-parturition. The suckling kids in T2 were provided with the newly formulated creep feed (*ad libitum* at 5% of body weight) besides receiving dam's milk according to the feeding program as shown in Table 1. During the lactation period, dams from both groups were fed with the same daily feed ration of 10% body weight with free access to water and mineral block. The feed ration for dams composed of dwarf Napier grass and commercial pellet (Soon Soon Sdn. Bhd., Prai, Pulau Pinang, Malaysia) at a ratio of 60:40.

Table 1: The feeding program for kids according to the experimental groups.

Time (h)	T1	T2
0900 – 1200	Water only	Creep feed
1200 – 1400	Free access to suckling	Free access to suckling
1400 – 1700	Water only	Creep feed
1800 – 0900	Free access to suckling	Free access to suckling

Note: T1, non-creep feeding; T2, creep feeding.

Preparation of creep feed

The ingredients and nutrient composition of the newly formulated creep feed pellet are shown in Table 2. The

formulation of creep feed was formulated based on the basic nutrient requirements for meat goats (NRC, 2007). The dwarf Napier grass (45-60 days of plant maturity) and *T. gigantea* leaves were harvested from UTAR Agricultural Park, Kampar, Perak. The tropical forages were subjected to 4 days full sunlight drying period from 9.00 am to 5.00 pm (Rahman *et al*., 2013; Kamruzali *et al*., 2021). All ingredients were ground into powder form, mixed, and pelletized.

Table 2: The dry matter (%) content of creep feed ingredients and composition.

Feed ingredient and composition	% (DM)
Palm kernel cake	10
Soybean meal	18
Soybean hull	10
Rice bran	7
Molasses	5
Broken rice	29
Dwarf Napier grass (as powder form)	10
Trichanthera gigantea leaf (as powder form)	10
Sodium chloride	0.5
Vitamin mineral premix	0.25
Enzyme, mannase	0.15
Probiotic plus powder	0.10
Chemical composition (dry matter basis)	
Gross energy (MJ/kg)	15.60
Dry matter (%)	90.06
Crude protein (%)	17.66
Crude fiber (%)	12.47
Ether extract (%)	2.27
Ash (%)	7.43
Calcium (%)	0.62
Phosphorus (%)	0.34

Nutrient analysis

Each feed ingredient and formulated ration were analyzed for dry matter (DM), CP, crude fiber (CF) and ash following the method of AOAC (2005). Briefly, the DM was determined by drying the samples in an oven at 105°C for 24 hr. The CP was determined by the Kjeldahl method, while the ether extract (EE) was determined using the Buchner funnel and applied with Solution A (chloroform and methanol) to extract the lipid (Folch *et al*., 1957). The CF was measured using the fiber bag system. Ash content was determined by using a muffle furnace at 550 °C for 5 hr. The gross energy was measured using the bomb calorimeter.

Parameters observed

The daily creep feed provided to the kids in T2 was recorded and the amount of remaining residue was recorded the next day at 9 am. The daily feed intake was calculated by using the feed given minus the remaining feed based on dry matter. The weight of the kids was measured every 14 days intervals for 90 days. The recorded weight gain was used to calculate the average daily gain (ADG). The ADG was calculated by using the total weight gain divided by the number of days between the period measured. The feed conversion ratio (FCR) was calculated by dividing total feed intake by total weight gain (TWG).

Statistical analysis

The FCR, average weight gain (AWG), total weight gain (TWG) and average daily gain (ADG) data were analyzed by T-test using SPSS V26.0. The level of significance used to determine the differences between treatments is at $P<0.05$.

RESULTS AND DISCUSSION

Nutrient composition of the creep feed

In this research, the newly formulated creep feed was able to meet the basic nutritional requirements of kids (Energy level: at least 6 MJ, dry matter: 84-90%, crude protein: 13-18%, crude fat: maximum 7%, crude fiber: at least 12%, crude ash: 5-9% and calcium to phosphate ratio is 2:1) according to DVS (2005), NRC (2007) and Jurgens *et al*. (2012). As shown in Table 2, the formulated creep feed contained 90.06% DM, 17.66% CP, 12.47% CF, 2.27% EE, 7.43% ash, 0.62% calcium, 0.34% phosphorus and 15.60 MJ gross energy.

Creep feed intake and growth performance of kids

The results on the average feed intake of male and female kids fed with creep feed are shown in Table 3. The total creep feed intake of male kids from day 14 till day 90 (17.54±0.95 kg) was significantly higher ($P<0.05$) compared to female kids (14.13±0.57 kg). Even though the overall feed intake of male kids was significantly higher than the female, the average feed intake between male and female kids at the beginning of the feeding trial day 14 to day 45 did not differ significantly ($P\geq0.05$). The trend of the feed intake increased steadily from day 14 to day 45. After two months, the feed intake from both male and female increased threefold. Interestingly, the average feed intake of male kids compared to female at day 60 till day 90 was significantly higher ($P<0.05$). Even though the total feed intake of the male was higher than the female, the FCR value for male kids (1.67) was lower than the FCR value for female kids (1.79). It was recorded those male kids had a higher feed intake and weight gain than the female kids, which resulted in male kids having a lower FCR value than the female kids.

Table 3: Creep feed intake of male and female kids in T2 group.

Parameters	Mean±SEM		P value
	Male	Female	
Feed intake (g/d) at			
Day 14	5.67±0.66	5.33±0.33	0.678
Day 30	60.67±16.84	83.67±8.21	0.287
Day 45	81.00±8.32	90.00±2.51	0.359
Day 60	449.33±32.04	301.67±16.66	0.024*
Day 75	490.67±1.76	354.00±38.37	0.024*
Day 90	508.33±2.96	393.30±8.82	0.003*
Total feed intake from day 14 to day 90 (kg)	17.54±0.95	14.13±0.57	0.038*
Feed conversion ratio	1.67±0.07	1.79±0.03	0.171

Note: T2, creep feed group; SEM, standard error mean. *P<0.05.

The birth weight of the kids used in this study regardless of sex ranged from 3.17±0.60 kg to 3.33±0.17 kg (Table 4). The weaning weight at day 90 for both male and female (19.67±1.04 kg and 15.83±0.17 kg) from the creep feeding (T2) group were significantly higher (p<0.05) than the full suckling (T1) group (13.67±2.18 kg and 13.13±0.88 kg. In terms of the average weight gain (AWG) shown in Table 4, the first 17 days (day 14 to day 30) of the creep feed feeding experiment (Male: 2.83±0.6 kg; Female: 1.5±0.01 kg) did not result in a significantly higher weight gain in T2 kids compared to the full suckling kids in T1 (Male: 2.00±1.04 kg; Female: 1.83±0.6 kg). However, the subsequent interval of 30 days of weight measurement (day 30 to day 90) showed that the kids fed with creep feed had significantly higher (p<0.05) weight gain than the full suckling kids. The total weight gain (TWG) of male and female kids (14.50±0.33 kg and 10.17±0.17 kg) fed with creep feed were also significantly higher (P<0.05) than the full suckling male and female kids (11.33±0.60 kg and 7.50±0.29 kg). The overall ADG of kids receiving the creep feed from day 14 to 90 (154.61±11.36 g/day) was significantly higher than the ADG of the full suckling kids (107.45±11.09 g/day) as shown in Figure 1. The overall comparison on the growth performance of kids in this study showed that the creep feeding (T2) group was better than the full suckling kids in T1 group, regardless of sex.

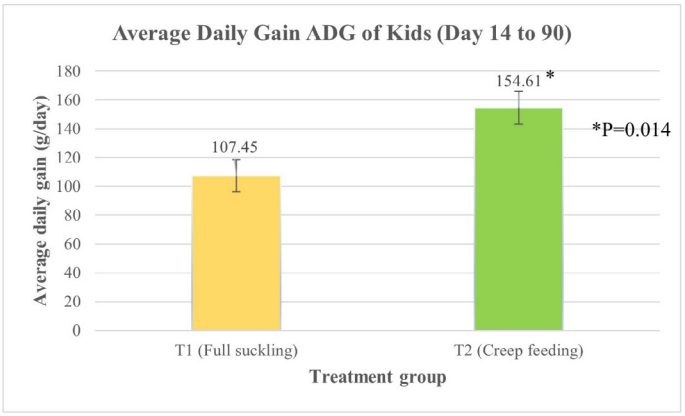

Figure 1: Average daily gains (g/day) of T1 and T2 kids from day 14-90.

Nutritional value of feed ingredients

Several researchers suggested that the basic nutritional requirement for suckling kids should have at least 6 MJ metabolizable energy/kg, 13% to 18% CP, not exceeding the permissible total fat content of 7%, minimum CF of 12% and calcium phosphorus ratio of 2:1 in creep feed (Ebert *et al.*, 2006; NRC, 2007; Rashid, 2008; Gurung, 2015). The nutrients composition (DM basis) of creep feed formulated in this study (Table 2) met the nutritional requirements of kids. In this research, the formulated creep feed consisted of 17.66% CP that was provided to the pre-weaning goat kids and it helped to increase weight gain. This finding is in agreement with the previous findings of Pond *et al.* (2005), Nezamidoust *et al.* (2015) and

Table 4: Average weight (kg) and weight gain (kg) of male and female kids from T1 and T2 groups.

Parameters	Mean±SEM					
	Male kids			Female kids		
	T1 (Full suckling)	T2 (Creep feed)	P value	T1 (Full suckling)	T2 (Creep feed)	P value
Weight (kg)						
At birth	3.17±0.17	3.33±0.17	0.519	3.17±0.60	3.33±0.17	0.802
At day 30	8.00±1.44	9.16±0.73	0.510	7.50±1.73	7.17±0.17	0.857
At day 60	10.17±1.76	12.50±0.76	0.322	9.50±1.73	10.17±0.17	0.721
At day 90	13.67±2.18	19.67±1.04	0.029*	13.18±0.88	15.83±0.17	0.041*
Weight gain (kg)						
Day 14-30	2.00±1.04	2.83±0.60	0.526	1.83±0.60	1.50±0.01	0.635
Day 30-60	3.17±0.33	5.00±0.01	0.032*	2.83±0.16	4.33±0.16	0.003*
Day 60-90	2.83±0.17	5.00±0.01	0.006*	2.17±0.44	5.00±0.01	0.003*
Day 14-90	11.33±0.60	14.50±0.33	0.027*	7.50±0.29	10.17±0.17	0.001*

Note: T1, non-creep feeding; T2, creep feeding; SEM, standard error mean. *P<0.05

Ma *et al.* (2017), who reported that creep feed consisting of high CP can help in the acceleration of rumen growth, improvement of feed intake and weight gain in small ruminants. The protein-rich feed consists of an adequate amount of amino acid that can be absorbed in small intestines where nutrient absorption is greater than ruminal fermentation and this feed can improve growth performance (Cash *et al.*, 2017).

Besides, maize is the most common ingredient that is used to formulate the creep feed for small ruminants because maize has a high energy content but low protein level (lysine and tryptophan) so it is required to fortify the creep feed with protein source ingredients such as soybean meal, soyhull, alfalfa, cotton seed and fish meal (Rios-Rincon *et al.*, 2014; Frasson *et al.*, 2018; Razali *et al.*, 2019). Soybean meal is the second most common ingredient in feed formulation because it contains methionine which helps to maintain a mutual balance of amino acid protein complementation in those pre-weaning ruminants (Bezbaruah *et al.*, 2020). The feed ingredients like maize, soybean meal and soyhull are imported ingredients in tropical countries like Malaysia. Consequently, the feed price becomes expensive when the inclusion of such ingredients in feed formulation is in a high ratio (Wahab, 2023). Hence, in this study, the maize was not included in the formulation of creep feed to reduce the reliance on importation of maize. In order to compensate the energy source from maize, this newly formulated creep feed utilized locally available PKC, rice by-product, *T. gigantea* leaf and Napier grass. This newly formulated creep feed that excluded maize could also fulfill the criteria of feed energy (15.60 MJ) for pre-weaning kids and subsequently reduce the feed price.

In previous ruminant feed formulation studies in the tropics, maize (37%), soyhull (34%) and PKC (22%) were used in the formulation of creep feed for Boer crossbred (Htoo *et al.*, 2015, 2018). When compared to the study by Htoo *et al.* (2018), the crude protein (14.2%) in the feed was relatively lower compared to the CP content in this study (17.6%). On the other hand, the crude fat or EE percentage in the feed formulated by Htoo *et al.* (2018) was relatively higher compared to the EE content in this study (2.2%). Even though the EE content in the formulated creep feed in this study is lower, the content is still within the nutrient requirement of not more than 7% of crude fat as recommended in goat feed (NRC, 2007). The higher EE content might be attributed by the maize and the higher percentage of PKC (22%) used in the feed formulation by Htoo *et al.* (2018).

According to the report by the Department of Veterinary Services (DVS) in Malaysia (Sudin *et al.*, 2005) and the analysis in this study, PKC was found to contain a high percentage of EE (15%). Hence, if a total mix ration of feed contains a high amount of PKC, the overall EE content in the feed formulated will be higher compared to other formulations that utilized lesser PKC (Rahman *et al.*, 2013). The creep feed formulated in this experiment has a higher CP content, but low EE content might be due to the inclusion of forage such as *Trichanthera gigantea* leaves and dwarf Napier grass (Table 2) that were known to be rich in protein (Budiman *et al.*, 2012; Kien *et al.*, 2020). Upon creep feeding trial using the listed formula as aforementioned in this research, the average weight gain of male kids in this study, 14.5 kg was relatively higher compared to the average weight gain of male kids, 11.4 kg in the creep feeding experiment done by Htoo *et al.* (2015).

The adoption of creep feeding regime in livestock farming has been reported to stimulate feed intake and improve the growth performance of pre-weaners (Cunha *et al.*, 2013; Ginting, 2019). Proper selection of feed ingredients is necessary because palatability is also the key factor in stimulating solid feed intake in suckling kids to prompt weight gain (Terblanche *et al.*, 2012). Other supplements that can assist in the suckling animals digestion such as probiotics and enzymes were also included in this study. Trace amounts of enzyme mannanase were added to help in breaking down the high non-starch polysaccharide in PKC (Chauhan *et al*, 2012) and probiotics were also included to optimize gut health conditions (Rashid, 2008), since the rumen microflora in the suckling kids is yet to be fully established (Hayes *et al.*, 2019). Hence, the addition of enzymes and probiotics may be contributing to the low FCR achieved in this experiment.

Creep feed intake and growth performance of kids

In this study, the total weight gain for male and female kids fed with creep feed in T2 group (14.50±0.33 and 10.17±0.17 kg, respectively) and weaning weight at day 90 (19.67±1.04 and 15.83±0.17 kg, respectively) were significantly ($P<0.05$) higher than the full suckling male and female kids in T1 groups with the total average weight gain of 11.33±0.60 kg and 7.50±0.29 kg, respectively during the first 3-months of birth. These findings are in line with the report by Goetsch *et al.* (2011) and Carvalho *et al.* (2022) who suggested that supplementing creep feed could boost post-weaning body weight and growth performance, especially if milk yield is insufficient, and that kids from single litters perform better than those from multiple litters. The weight gain and average weaning weight of male and female kids (19.67±1.04 and 15.83±0.17 kg, respectively) in this study were relatively higher compared to other creep feed studies on meat breed goats reported by Htoo *et al.* (2015) (12.1 kg) and Hayes *et al.* (2018) (15.00 kg).

In terms of the average weight gain (AWG) from day 14

to day 30, both creep-fed kids (T2) and full-suckling kids (T1) did not show significant (P ≥ 0.05) differences. This result might be due to the creep feed kids (male and female) consuming less amount of creep feed during the initial exposure of the kids to the solid creep feed in the first few weeks of the feeding trial. Once the kids adapted to the creep feeding regime, an obvious threefold increase in feed intake was observed from day 60 till day 90. Similar observations were reported by Vickery *et al.* (2023) that when the creep feed kids start to nibble more creep feed on 45 to 60 days old, the weight gain escalated. The study by (Alemu and Merkel, 2016) also suggested that the consumption of creep feed is usually low at the initial age until kids reach 8 to 10 weeks old.

In terms of the average daily gain (ADG), kids from the creep feed group showed a significantly higher ADG compared to the full-suckling kids. The ADG of kids fed with creep feed in this study (154.61 g) in this study was relatively higher than the ADG of creep-fed kids (102.9 g) reported by Htoo *et al.* (2015). The differences in ADG are likely attributed to the difference in the creep feed formulation and nutrient content of the creep feed. Early transition from milk dependence to solid feed is crucial for newborn kids to achieve optimal growth as it plays an essential role in stimulating rumen development (Grecco *et al.*, 2020; Da Silva *et al.*, 2022). Creep feed is suggested to be provided to kids to stimulate the rumen microbes because goats rely on rumen microbes to convert creep feed into usable energy for growth (Htoo *et al.*, 2018).

Feed conversion ratio

In this study, the FCR values between male and female kids in the creep feed group (Table 3) did not differ significantly (P≥0.05). Male kid had lower FCR value compared to females because males have a better total weight gain to feed intake ratio compared to females as shown in Tables 3 and 4. This is agreed by Muola *et al.* (1999), who mentioned that female kids consume less dry matter than male kids, and male kids had been reported to have significantly greater in feed conversion efficiency, slaughter weight, and live weight gain than female kids. In contrast, higher FCR values were observed from studies by Razali *et al.* (2019) (2.21) and Htoo *et al.* (2018) (2.15), while in this experiment the FCR value was 1.73. Theoretically, a low FCR will provide a better feed-to-meat ratio conversion compared to a high FCR. Besides achieving a lower FCR in this study, the used of creep feed in this study showed a relatively better weaning weight at day 90 compared to the previous studies (Razali *et al.*, 2019; Htoo *et al.*, 2018).

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the newly formulated creep feed using locally available feed ingredients could be fed as a supplement to pre-weaning kids without any negative effects. The growth performance of pre-weaning kids (male or female) improves significantly when the formulated creep feed is offered. Furthermore, male kids fed creep feed gained significantly more than female kids. The newly formulated creep feed has the potential to effectively improve nutrients utilization while also reducing feed costs.

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NOVELTY STATEMENT

In this study, a novel feeding schedule is introduced, incorporating a creep feed formulated with palm kernel cake and tropical forages for Boer crossbreed kids. The goal of this research is to evaluate its potential in improving growth rates, feed utilization, and overall performance in small ruminant production systems.

AUTHOR'S CONTRIBUTION

The experiment was planned and executed by XY, PJ, CY and FF. The manuscript were prepared by XY under the guidance of PJ and CY. Substantial revision to the manuscript were made by PJ, CY, MMR, and FF. The submitted version has been approved by all authors.

Conflict of interest

The authors have declared no conflict of interest.

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