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Allometric Growth Patterns of Native Chickens Supplemented with Fermented Papaya Seed and Dragon Fruit Peel Extracts in Drinking Water

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Abstract— *Native chickens are widely raised in Indonesia due to their adaptability, distinctive meat characteristics, and economic value. However, their growth performance is generally lower than that of commercial broiler chickens, creating a need for natural feed additives to improve productivity. This study aimed to evaluate the effects of fermented papaya seed (*Carica papaya*) and dragon fruit peel (*Hylocereus *spp.) extracts administered through drinking water on the allometric growth patterns of native chickens. A completely randomized design consisting of four treatments and five replications was employed. The treatments included drinking water without fermented extract (P0), drinking water supplemented with 4% fermented papaya seed extract (P1), 4% fermented dragon fruit peel extract (P2), and a combination of 2% fermented papaya seed extract and 2% fermented dragon fruit peel extract (P3). Body weight and morphometric parameters, including neck length, body length, wing length, upper thigh length, lower thigh length, shank length, chest width, and chest circumference, were measured and analyzed using a power regression model ($Y = aX^b$) to determine relative growth coefficients. The results showed that the correlation coefficient (r) ranged from 0.622 to 0.956, indicating strong to very strong relationships between body weight and morphometric traits across all treatments. All observed parameters showed relative growth coefficient values of $b < 1$, indicating negative allometric growth patterns. The combination treatment (P3) tended to produce the highest body weight compared to the other treatments, suggesting improved nutrient utilization efficiency and growth performance. In conclusion, supplementation with fermented papaya seed and dragon fruit peel extracts through drinking water influenced the growth performance of native chickens while maintaining negative allometric growth patterns in body morphometric development.*

Keywords— Allometric growth, native chicken, fermented papaya seed, dragon fruit peel, morphometric traits, phytogenic additive.

I. INTRODUCTION

Native chickens are one of the most important local poultry commodities in Indonesia due to their adaptability, distinctive meat characteristics, and stable economic value. In addition to being widely preferred by consumers, native chickens are commonly raised under traditional or semi-intensive farming systems because they require relatively simple management and are more resistant to environmental stress than commercial broiler chickens. However, compared with modern broiler strains, native chickens generally exhibit slower growth rates and lower production efficiency, which limits their productivity and commercial potential. Therefore, alternative nutritional strategies are needed to improve their growth performance in a sustainable and environmentally friendly manner [1].

The utilization of agricultural by-products as natural feed additives has recently attracted considerable attention in poultry production. Among these by-products, papaya seeds (*Carica papaya*) and dragon fruit peel (*Hylocereus* spp.) possess significant potential due to their nutritional and bioactive compound contents. Papaya seeds contain protein, essential fatty

acids, flavonoids, phenolic compounds, and papain enzymes that may improve digestive efficiency and inhibit pathogenic microorganisms in the gastrointestinal tract [2]. Meanwhile, dragon fruit peel is rich in dietary fiber, anthocyanins, polyphenols, and natural antioxidants that can support physiological health and reduce oxidative stress in poultry [3]. These compounds are considered beneficial as phytogenic feed additives capable of enhancing nutrient utilization and growth performance in chickens.

Fermentation is one of the most effective methods for improving the nutritional quality and functional properties of agricultural waste materials. The fermentation process can reduce antinutritional compounds, increase nutrient availability, improve digestibility, and produce beneficial metabolites such as organic acids and probiotic microorganisms [4]. Fermentation using Effective Microorganisms 4 (EM4) has been widely applied in livestock production because it contains beneficial microbial populations, including *Lactobacillus* spp. and *Saccharomyces* spp., which contribute to maintaining intestinal microbial balance and improving digestive health (Nurhayati et al., 2022). Previous studies have reported that fermented phytogenic materials may improve growth performance, feed efficiency, and physiological conditions in poultry. In addition, supplementation of fermented dragon fruit peel through drinking water has been shown to increase body weight and improve feed utilization efficiency in local chickens and quails [5].

Most previous studies involving fermented phytogenic additives in poultry have mainly focused on general production parameters such as body weight gain, feed conversion ratio, and carcass performance. However, information regarding the relationship between body weight and morphometric body development, particularly through allometric growth analysis, remains limited. Allometric analysis is important because it describes the proportional relationship between body size and body weight during growth. This approach can provide a more comprehensive understanding of skeletal and morphological development in poultry, including changes in neck length, body length, wing length, leg dimensions, chest width, and chest circumference relative to body weight gain [6].

In poultry science, allometric growth analysis is commonly performed using the power regression model ($Y = aX^b$), where Y represents body morphometric measurement, X represents body weight, a is a constant, and b represents the relative growth coefficient. A coefficient value of $b > 1$ indicates positive allometric growth, $b = 1$ indicates isometric growth, and $b < 1$ indicates negative allometric growth. Understanding these growth patterns is important for evaluating body development, growth efficiency, and potential carcass characteristics in native chickens [7]. According to Sampurna [10], the power regression model is widely used to evaluate relative growth rates between body weight and body morphometric traits in poultry.

Despite the increasing interest in phytogenic fermentation products, studies investigating the effects of fermented papaya seed and dragon fruit peel supplementation through drinking water on the allometric growth patterns of native chickens are still very limited. Furthermore, the combined use of these two fermented materials and their influence on morphometric body development has not been extensively explored. Therefore, this study aimed to evaluate the effects of fermented papaya seed and dragon fruit peel extracts administered through drinking water on the allometric growth patterns of native chickens by analyzing the relationship between body weight and body morphometric traits using a power regression approach.

II. MATERIALS AND METHODS

2.1 Place and Time of the Research

This research was conducted at the poultry research facility of the Faculty of Animal Husbandry, Udayana University, located in Denpasar, Bali, Indonesia. The study was carried out from the preparation stage, fermentation process, chicken maintenance, data collection, and data analysis for approximately two months.

2.2 Experimental Chickens

The experimental animals used in this study were 40 female native chickens aged 10 weeks at the beginning of the experiment. The chickens were selected based on uniform body weight and maintained until 15 weeks of age under similar environmental and management conditions.

2.3 Cages and Equipment

The chickens were reared in colony cages under uniform management conditions. Each experimental unit consisted of two chickens per cage. The equipment used in this study included digital scales for body weight measurement, measuring tapes for morphometric observations, plastic containers for fermentation, blenders for processing papaya seeds and dragon fruit peel, strainers for separating the filtrate, drinkers, feeders, and stationery for data recording.

2.4 Feed and Drinking Water

Commercial native chicken feed was provided throughout the experimental period. Feed and drinking water were administered ad libitum. The drinking water treatments consisted of fermented papaya seed extract and fermented dragon fruit peel extract according to the assigned treatment groups. Clean water was used as the base drinking water source.

2.5 Research Design

This study used a Completely Randomized Design (CRD) consisting of four treatments and five replications, with each replication consisting of two female native chickens. The treatments administered through drinking water were as follows:

1) P0: Drinking water without fermented extract (control)
2) P1: Drinking water with 4% fermented papaya seed extract
3) P2: Drinking water with 4% fermented dragon fruit peel extract
4) P3: Drinking water with a combination of 2% fermented papaya seed extract and 2% fermented dragon fruit peel extract

Each experimental unit received approximately 1,000 mL of drinking water daily according to the assigned treatment.

2.6 Preparation of Fermented Extracts

Papaya seeds (*Carica papaya*) and dragon fruit peel (*Hylocereus* spp.) were washed thoroughly and weighed at 1 kg each. The materials were blended separately with 1 L of clean water until homogeneous. The mixtures were then filtered to separate the liquid extract from the residue. Subsequently, EM4 (Effective Microorganisms 4) and one tablespoon of sugar were added to each filtrate and mixed evenly. Fermentation was carried out in closed containers at room temperature for five days.

2.7 Administration of Fermented Extracts

The fermented extracts were administered through drinking water during the experimental period from 10 to 15 weeks of age. The treatments were prepared as follows:

1) P0: 100% drinking water without fermented extract
2) P1: 96% drinking water + 4% fermented papaya seed extract
3) P2: 96% drinking water + 4% fermented dragon fruit peel extract
4) P3: 96% drinking water + 2% fermented papaya seed extract + 2% fermented dragon fruit peel extract

Drinking water was provided continuously throughout the day and replaced daily according to the respective treatments.

2.8 Observed Variables

The observed variables included body weight and body morphometric measurements. Body weight was measured using a digital scale before morning feeding and recorded in grams. Morphometric measurements were obtained using a measuring tape while the chickens were standing in an upright position. The measured morphometric traits included neck length, body length, wing length, upper thigh length, lower thigh length, shank length, chest width, and chest circumference. Measurement procedures followed the poultry morphometric method described by Chebo et al. (2024). All measurements were performed by the same researcher to minimize observer bias.

2.9 Data Analysis

The relationship between body weight and body morphometric measurements was analyzed using the power regression model:

$$\mathbf{Y = aX^b} \quad \textbf{(1)}$$

Where:

- Y = body morphometric measurement
- X = body weight
- a = regression constant
- b = relative growth coefficient

The coefficient value (b) was used to determine the allometric growth pattern, where b > 1 indicated positive allometric growth, b = 1 indicated isometric growth, and b < 1 indicated negative allometric growth. Correlation coefficients (r) were also used to evaluate the strength of the relationship between body weight and body morphometric traits. The log-transformed form of the equation was used for analysis:

$$\log(Y) = \log(a) + b \log(X) \quad (2)$$

III. RESULTS AND DISCUSSION

3.1 Allometric Growth Analysis

Table 1 presents the allometric analysis of body morphometric traits of native chickens supplemented with fermented papaya seed and dragon fruit peel extracts.

TABLE 1
ALLOMETRIC ANALYSIS OF BODY MORPHOMETRIC TRAITS OF NATIVE CHICKENS

Treatment	Body Morphometric Traits (cm)	Correlation Coefficient (R)	Constant (a)	Relative Growth Coefficient (b)	Allometric Equation
P0	Neck length	0.654	0.4	0.503	Y_{01} = 0.400X^0.5030
	Body length	0.622	1.361	0.374	Y_{02} = 1.361X^0.3740
	Wing length	0.763	1.259	0.383	Y_{03} = 1.259X^0.3830
	Upper thigh length	0.895	0.052	0.779	Y_{04} = 0.052X^0.7790
	Lower thigh length	0.854	0.629	0.43	Y_{05} = 0.629X^0.4300
	Shank length	0.878	0.261	0.575	Y_{06} = 0.261X^0.5750
	Chest width	0.838	0.116	0.642	Y_{07} = 0.116X^0.6420
	Chest circumference	0.821	1.497	0.412	Y_{08} = 1.497X^0.4120
P1	Neck length	0.877	0.148	0.65	Y_{11} = 0.148X^0.6500
	Body length	0.866	0.911	0.438	Y_{12} = 0.911X^0.4380
	Wing length	0.853	0.889	0.442	Y_{13} = 0.889X^0.4420
	Upper thigh length	0.895	0.21	0.562	Y_{14} = 0.210X^0.5620
	Lower thigh length	0.849	0.499	0.271	Y_{15} = 0.499X^0.2710
	Shank length	0.811	1.338	0.332	Y_{16} = 1.338X^0.3320
	Chest width	0.85	0.121	0.633	Y_{17} = 0.121X^0.6330
	Chest circumference	0.866	2.236	0.352	Y_{18} = 2.236X^0.3520
P2	Neck length	0.841	0.071	0.752	Y_{21} = 0.071X^0.7520
	Body length	0.956	0.683	0.469	Y_{22} = 0.683X^0.4690
	Wing length	0.953	0.317	0.577	Y_{23} = 0.317X^0.5770
	Upper thigh length	0.875	0.035	0.817	Y_{24} = 0.035X^0.8170
	Lower thigh length	0.689	0.756	0.4	Y_{25} = 0.756X^0.400
	Shank length	0.826	1.052	0.365	Y_{26} = 1.052X^0.3650
	Chest width	0.934	0.104	0.648	Y_{27} = 0.104X^0.6480
	Chest circumference	0.922	0.986	0.469	Y_{28} = 0.986X^0.4990
P3	Neck length	0.797	11.369	0.002	Y_{31} = 11.369X^0.0020
	Body length	0.658	16.431	0.002	Y_{32} = 16.431X^0.0020
	Wing length	0.877	9.532	0.007	Y_{33} = 9.532X^0.0070
	Upper thigh length	0.856	1.627	0.334	Y_{34} = 1.627X^0.3340
	Lower thigh length	0.716	1.08	0.319	Y_{35} = 1.080X^0.3190
	Shank length	0.877	0.864	0.388	Y_{36} = 0.864X^0.3880
	Chest width	0.93	0.574	0.407	Y_{37} = 0.574X^0.4070
	Chest circumference	0.944	3.113	0.308	Y_{38} = 3.113X^0.3080

Note: P0 = drinking water without fermented extract (control); P1 = drinking water with 4% fermented papaya seed extract; P2 = drinking water with 4% fermented dragon fruit peel extract; P3 = drinking water with a combination of 2% fermented papaya seed extract and 2% fermented dragon fruit peel extract.

3.2 Correlation Analysis

Based on Table 1, the correlation coefficient (R) values ranged from 0.6220 to 0.9560, indicating strong to very strong relationships between body weight and body morphometric traits in native chickens. These findings demonstrated that increases in body weight were consistently followed by increases in morphometric measurements across all treatments. According to Genevieve and Ogagaoghene [6], body morphometric traits are strongly associated with skeletal and physiological development in poultry.

3.3 Allometric Growth Patterns

All observed morphometric traits showed relative growth coefficient values ($b < 1$), indicating negative allometric growth patterns. This result suggests that body morphometric development occurred at a slower rate than body weight gain. Negative allometric growth generally indicates that skeletal growth approaches maturity earlier than muscle and fat deposition. Consequently, increases in body weight during later growth phases are more closely associated with soft tissue accumulation rather than skeletal elongation. Similar findings were reported by Isaac et al. [7], who stated that body morphometric growth in poultry commonly slows relative to body weight gain during advanced growth phases.

3.4 Treatment Effects

The control treatment (P0) showed correlation coefficient values ranging from 0.6220 to 0.8950, with all body morphometric parameters exhibiting negative allometric growth patterns. Similar growth patterns were also observed in treatments P1, P2, and P3, indicating that supplementation with fermented papaya seed extract, fermented dragon fruit peel extract, or their combination did not alter the overall proportional growth pattern of native chickens. However, supplementation treatments tended to improve body weight development compared with the control treatment.

Among all treatments, the combination treatment (P3) tended to produce better growth performance. This result was likely associated with the synergistic effects of fermented papaya seed and dragon fruit peel extracts in improving nutrient utilization and digestive health. Papaya seeds contain papain enzymes, flavonoids, and phenolic compounds that may improve protein digestion and inhibit pathogenic microorganisms in the digestive tract [2]. Meanwhile, dragon fruit peel contains anthocyanins, polyphenols, and antioxidant compounds that may support intestinal health and physiological functions in poultry [3].

The fermentation process may also contribute to improved nutrient digestibility and bioavailability through the production of beneficial microorganisms and organic acids. Fermented phytogenic additives have been reported to improve intestinal microbial balance, digestive enzyme activity, and nutrient absorption efficiency in poultry [4]. Consequently, chickens receiving combined fermented extracts may have utilized nutrients more efficiently for body growth and physiological development.

Although supplementation treatments improved growth performance, the negative allometric growth pattern remained consistent across all treatments. This finding suggests that supplementation mainly enhanced physiological growth performance and nutrient utilization rather than altering the proportional pattern of skeletal development in native chickens. Overall, the results indicate that fermented papaya seed and dragon fruit peel extracts may serve as potential natural phytogenic additives to support native chicken growth performance while maintaining normal allometric growth characteristics.

3.5 Graphical Representation

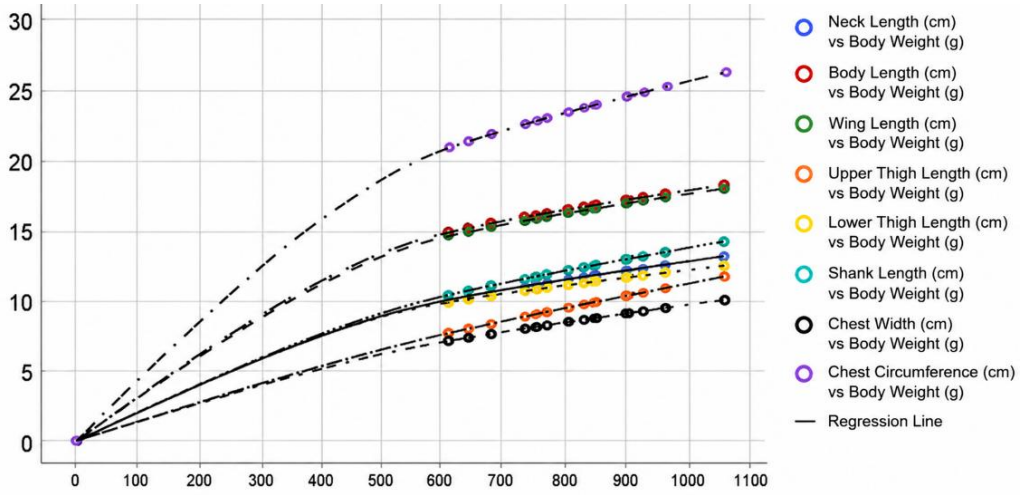

FIGURE 1. Allometric Growth Pattern of Native Chickens in Control Treatment (P0)

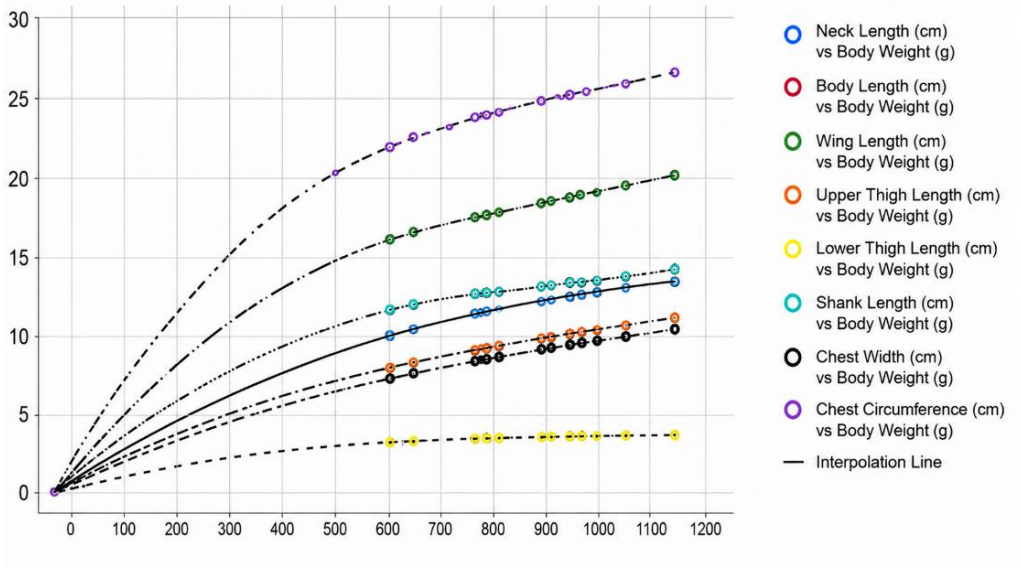

FIGURE 2: Allometric Growth Pattern of Native Chickens Supplemented with 4% Fermented Papaya Seed Extract (P1)

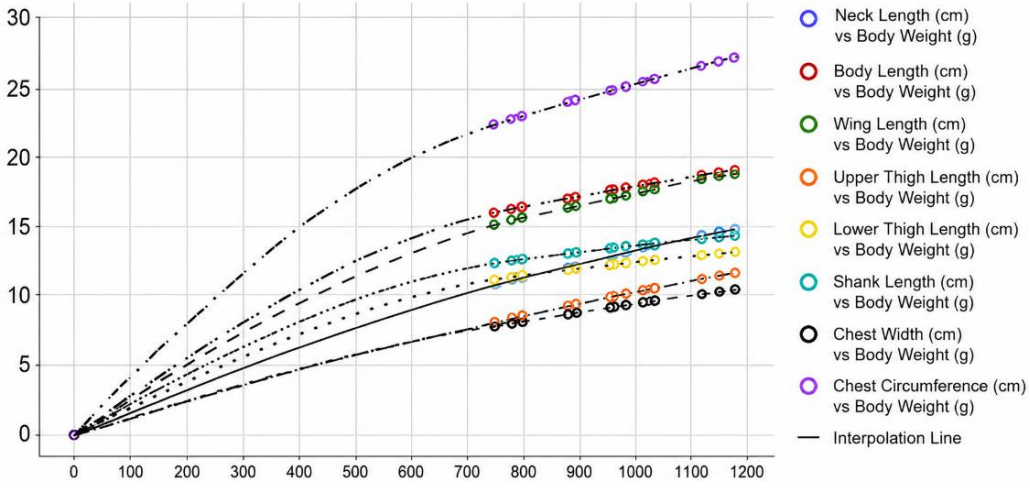

FIGURE 3: Allometric Growth Pattern of Native Chickens Supplemented with 4% Fermented Dragon Fruit Peel Extract (P2)

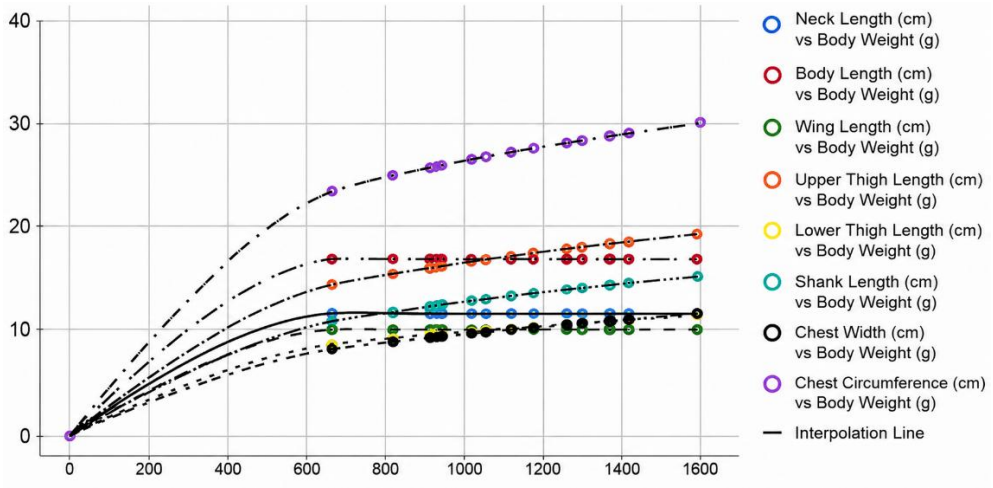

FIGURE 4: Allometric Growth Pattern of Native Chickens Supplemented with a Combination of Fermented Papaya Seed and Dragon Fruit Peel Extracts (P3)

3.6 Interpretation of Allometric Patterns

Figures 1–4 illustrate the relationship between body weight and body morphometric traits in native chickens under each treatment. In all treatment groups, body morphometric measurements increased as body weight increased. The regression lines demonstrated positive relationships between body weight and body dimensions, although all relative growth coefficients (b) remained below 1, indicating negative allometric growth patterns. Among the treatments, P3 tended to exhibit higher body weight distribution and morphometric development compared with the other treatments, suggesting improved growth performance associated with combined fermented extract supplementation.

Note on P3 low b values: The extremely low b values observed in P3 for neck length (0.002), body length (0.002), and wing length (0.007) warrant discussion. These values suggest that in the combination treatment, these morphometric traits showed almost no proportional increase with body weight gain. This may indicate that the synergistic effects of the combined extracts influenced nutrient partitioning toward muscle and organ development rather than skeletal elongation. Alternatively, this could reflect the specific growth stage of the chickens (10-15 weeks) where skeletal growth is already approaching maturity. Further research is needed to confirm this observation.

IV. CONCLUSION

Supplementation of fermented papaya seed (*Carica papaya*) and dragon fruit peel (*Hylocereus* spp.) extracts through drinking water influenced the growth performance of native chickens and showed strong relationships between body weight and body morphometric traits. All observed morphometric parameters exhibited negative allometric growth patterns ($b < 1$), indicating that body morphometric development occurred more slowly than body weight gain. The combination treatment consisting of 2% fermented papaya seed extract and 2% fermented dragon fruit peel extract tended to provide better growth performance compared with the other treatments. Therefore, fermented papaya seed and dragon fruit peel extracts have potential as natural phytogenic additives for improving the growth performance of native chickens.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research

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