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Performance and Carcass Characteristics of Broiler Chicken Fed Soybean and Sesame/Soybean Based Diets Supplemented With or Without Microbial Phytase

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Authors' contributions

This work was carried out in collaboration between all authors. Author ABO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author ABO performed the statistical analysis. Authors TAO and OOO managed the analyses of the study. Author ADO managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: The experiment was conducted to investigate the performance and carcass characteristics of meat-type chicken fed Soybean Meal (SBM) and Sesame/Soybean Meal (SSBM) supplemented with or without microbial phytase.
Study Design: The experiment employed a complete randomized design; all data generated were subjected to analysis of variance, P=0.05.
Place and Duration of Study: The study was carried out at the Teaching and Research Farm of the University of Ibadan, Nigeria, between October and December, 2011.
Methodology: One hundred and sixty-eight unsexed two weeks old Arbor Acre strain chickens were used in a 35-day feeding trial. Two feeding regimes of soybean meal and Sesame/soybean meal based diets were formulated. Each feeding regime comprised of control diet and two levels of phytase units (300 and 600 FTU/kg) of 500 unit /g activity making a total of six dietary treatments. The birds were fed the experimental diets for a 35-

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day period during which data were obtained on Feed Intake (FI), Body Weight Gain (BWG) and Feed Conversion Ratio (FCR). At the end of the feeding trial, three birds were slaughtered per replicate to evaluate carcass and meat characteristics.
Results: The addition of phytase improved the birds' performance, FI and FCR. Significant (P<0.05) increase was obtained for apparent retention of nitrogen (67.22%), ash (74.85%), ether extract (65.43%), crude fibre (76.22%) and Phosphorus (45.58%). Cooking loss values increased while the Water Holding Capacity (WHC) reduced with microbial phytase supplementation.
Conclusion: Sesame/soybean diet supplemented with 300 FTU/Kg microbial phytase gave optimum performance and should probably be adopted as the feeding regime of choice since it also resulted in better nutrient utilization by the birds.

Keywords: Microbial phytase; soybean meal; sesame; broiler chicken, performance.

1. INTRODUCTION

Plant materials are the major constituents of poultry diets. Unfortunately, about two-third of the phosphorus (P) in cereal grains, oilseed meals and plant by- products is present in the form of P bound to phytic acid (phytate P), which is not available to poultry. Corn-soybean diets are rich in phytic acid which is not available for non-ruminant animals. Most of the phytate phosphorus is discharged along with excrement thereby leading to waste of resource and increase environmental pollution.

Soybean is a major plant protein source used in poultry ration formulation essentially for its high lysine content. Sesame seed (*Sesamum indicum*) is another plant protein source produced locally and it has appreciable amount of methionine [1]. When used in the right proportions together with soybean meal which has a higher content of lysine; a balanced diet with respect to lysine and methionine will result [2]. Incidentally, both plants are high in phytic phosphorus which reduces their phosphorus and calcium availability however, this adverse effect could possibly be overcome by dietary supplementation with exogenous phytase [3].

Enzyme such as microbial phytase has been used as commercial feed additive in broiler feed production to improve nutritive values of plant based diets. Addition of microbial phytase to broiler diet leads to hydrolysis of phytate, which bind phosphorus of the plant based diet [4,5]. Moreover, interest in the use of phytase as feed additive has now increased due to problems posed by phosphates in animal wastes. Phytic acid is generally regarded as being resistant to hydrolysis in the avian gut due to lack of endogenous phytase. Inclusion of exogenous enzyme in animal's diet has been shown to improve broiler's performance [6] but the effect on meat quality has to be determined as certain feed additives have been found to affect meat qualities. Hence this study was initiated to ascertain the effect of feeding soybean and sesame/soybean based diets supplemented with or without phytase on performance and meat characteristics of broiler chicken and also to investigate the utilization and excretion of N and P by poultry and develop dietary strategies for improving their utilisation and reduce their contribution to environmental pollution.

2. MATERIALS AND METHODS

A total of one hundred and sixty eight unsexed 1-day old Arbor Acre plus strain of broiler chicks were purchased from a commercial hatchery. The chicks were brooded for two weeks and were randomly allotted to six dietary treatments of 4 replicates each with 7 birds per replicate in a completely randomized design. Two basal diets based on corn-soybean meal and corn-sesame/soybean meal was formulated. Microbial phytase concentrations of 0, 300 and 600 phytase units (FTU/ kg) were added to the basal diet resulting in the following six treatments:

Soybean + 0 FTU/kg
Soybean + 300 FTU/kg
Soybean + 600 FTU/kg
Sesame / Soybean + 0 FTU/kg
Sesame /Soybean + 300 FTU/kg
Sesame /Soybean + 600 FTU/kg

The microbial phytase (E.C.3.1.3.8) used was Natuphos® 5000, a commercial preparation with a Phytase activity of 5000 Unit/g.

2.1 Feed Intake and Weight Gain

The chicks were given a free choice access to diets and fresh cool water throughout the experimental period which comprised of two phases, 3-4 and 5-7 weeks representing the starter and finisher phase respectively. The feed intake and body weight gain were taken on weekly basis. Weight gain was determined as difference between initial weight and final weight. Feed conversion ratio (FCR) was determined based on the average feed intake and average body weight gain.

$$FCR = \frac{\text{Average feed consumed (g)}}{\text{Average body weight gain (g)}}$$

The gross compositions of the experimental diets are shown in Tables 1 and 2.

2.2 Nutrient Retention

At the end of the feeding trial, three birds per replicate were selected at random and housed individually in metabolic cages for nutrient retention trials. The birds were fed 75% of their daily feed requirement to ensure complete consumption. The birds were allowed a four day adjustment period, while fecal samples were collected for three days. At the end of the fecal collection period, representative samples of the excreta were dried in an oven at 60ºC until constant weight was obtained and ground to pass through 1 mm sieve. The ground excreta samples were analyzed for total nitrogen (N), crude fiber, fat, ash and phosphorus [7]. All calculations were expressed on Dry Matter (DM) basis. The difference in the nutrient content of the feed consumed and of the feaces voided was used to calculate the retention of nutrients.

Table 1. Gross composition of the starter diet (%)

Ingredients	Treatments					
	T1	T2	T3	T4	T5	T6
Maize	53.10	53.10	53.10	48.00	48.00	48.00
Soybean	34.60	34.60	34.60	28.60	28.60	28.60
Sesame	-	-	-	13.10	13.10	13.10
Wheat offal	5.00	5.00	5.00	4.00	4.00	4.00
Fish meal (72%)	2.50	2.50	2.50	2.50	2.50	2.50
Palm oil	2.00	2.00	2.00	1.00	1.00	1.00
*Premix	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Di calcium phosphate	2.05	2.05	2.05	2.05	2.05	2.05
Salt	0.25	0.25	0.25	0.25	0.25	0.25
**Phytase	-	0.06	0.12	-	0.06	0.12
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients						
M KCal/Kg	2972	2972	2972	3300	3300	3300
Crude protein	23.26	23.26	23.26	23.10	23.10	23.10
Total Phosphorus	0.85	0.85	0.85	0.87	0.87	0.87
Calcium	1.67	1.67	1.67	1.72	1.72	1.72

*** Not included as part of the formulation but added as supplement to the basal diet*
**2.5 kg Premix used supplied vitamin A, 12,500000iv: vitamin D, 2500000iv; vitamin E,40,000mg; vitamin K3,2000mg;vitamin B1, 3000mg; vitamin B2 5500mg Niacin, 55000mg;calcium pantothenate, 11500mg vitamin B6, 5000mg; vitamin B12, 25mg; Folic acid,1000mg;biotin,80mg;choline chloride 500000mg;manganese, 120000mg; Iron100,000mg;zinc,80000mg;copper 8500mg;iodine 1500mg cobalt 3000mg;selenium 120mg and anti-oxidant 120,000mg; T_1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase; T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase;T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase*

2.3 Carcass Cut Up

At the end of the feeding trials, 3 birds in each of the replicate groups whose weight was close to the average of the group were purposively selected, fasted for twelve hours and sacrificed to evaluate carcass and meat characteristics. The birds were weighed and slaughtered in batches of six according to the method described by [8]. The slaughtered birds were properly bled, defeathered and eviscerated. The eviscerated birds were dissected and all internal and external offal carefully removed. The hot carcasses were weighed to obtain the dressed weight; the carcasses were later chilled before they were dissected into primal cuts.

2.4 Meat Quality Study

2.4.1 Percentage cooking loss

Meat samples (20g) were taken from the breast muscle, thigh and drumstick of each carcass and cooked to an internal temperature of 72ºC in a moist-heat cookery method. The water released after cooking and cooling was manually separated and the weight of the cooked meat taken to obtain the cooking loss.

Percentage cooking loss was calculated as:

$$\frac{\text{(Weight of sample before cooking – weight after cooking)}}{\text{Weight of sample before cooking}} \times 100$$

Table 2. Gross composition of finisher's diet (%)

Ingredients	Treatments					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
Maize	59.30	59.30	59.30	54.20	54.20	54.20
Soybean	28.40	28.40	28.40	22.40	22.40	22.40
Sesame	-	-	-	13.10	13.10	13.10
Wheat offal	4.00	4.00	4.00	4.00	4.00	4.00
Fish meal	2.50	2.50	2.50	2.50	2.50	2.50
Palm oil	3.00	3.00	3.00	1.00	1.00	1.00
*Premix	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
DCP	2.05	2.05	2.05	2.05	2.05	2.05
Salt	0.25	0.25	0.25	0.25	0.25	0.25
**Phytase	-	0.06	0.12	-	0.06	0.12
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients						
M Kcal/Kg	3061	3061	3061	3363	3363	3363
Crude Protein	21.02	21.02	21.02	21.09	21.09	21.09
Phosphorus	0.75	0.75	0.75	0.77	0.77	0.77
Calcium	1.52	1.52	1.52	1.57	1.57	1.57

** *Not included as part of the formulation but added as supplement to the basal diet *2.5 kg Premix used supplied vitamin A, 12,500000iv: vitamin D, 2500000iv; vitamin E,40,000mg; vitamin K3,2000mg;vitamin B1, 3000mg; vitamin B2 5500mg Niacin, 55000mg;calcium pantothenate,11500mg vitamin B6, 5000mg; vitamin B12, 25mg; Folic acid,1000mg;biotin,80mg;choline chloride500000mg;manganese, 120000mg; Iron100,000mg;zinc,80000mg;copper 8500mg;iodine 1500mg;cobalt 3000mg;selenium 120mg and anti-oxidant 120,000mg; T_1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase; T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase; T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase*

2.4.2 Water Holding Capacity (WHC)

This was determined in triplicate by the press method of [9] with slight modification. Approximately 1.0g samples from breast muscle, drumstick and thigh were weighed individually into a 9cm Whatman No 1 filter paper and pressed between two 10.2x10.2 cm plexi glasses and pressed at approximately 35.2kg/cm^3 for a minute. The area of free water was measured using a compensatory planimeter (Planix 5000, Tamaya Technics, Inc., Tokyo, Japan) and percentage free water was calculated based on sample weight and moisture content [9] while percentage bound water or water holding capacity was calculated as 100% minus free water %.

2.4.3 Chilling loss

A known weight of meat was chilled at 4ºC for 24 hours, after which the meat was thawed and weighed. Chilling loss was calculated as follows:

$$\text{Chilling loss (\%)} = \frac{\text{Initial weight (before chilling)} - \text{Final weight (after chilling)}}{\text{Initial weight (before chilling)}} \times 100$$

2.4.4 Shear force

Shear force was determined using the modified Warner Braztler shear force procedure. Meat samples from the breast, drum stick and thigh muscles were cooked to an internal temperature of 72ºC. The cooked samples were allowed to equilibrate to room temperature (27ºC). Three cores of 1.0 cm diameter were removed from each cooked meat sample. Each core was sheared at three locations perpendicular to the orientation of the muscle fibre. The average of the three muscle types were taken and recorded as the shear force value for each treatment.

2.5 Statistical Analysis

All data obtained were subjected to statistical analysis of variance. The analysis was conducted using the general linear modeling procedure SAS [10] and the means were separated using Duncan Multiple Range Test of the same software.

3. RESULTS AND DISCUSSION

The effects of different dietary treatment on performance characteristics of broiler chicks are summarized in Table 3. There was no significant difference (P >0.05) among the treatments in terms of initial weight. Final weight obtained showed that birds on diets supplemented with microbial phytase in each of the feeding regime were significantly higher (P<0.05) compared with those on the respective control diets. The results of the present experiment showed that broiler chickens fed phytase supplemented diets had better performance in terms of weight gain and FCR. Earlier studies [11,12,13,14] demonstrated that broiler chickens fed diets supplemented with microbial phytase has improved feed conversion ratio due to better feed utilization. In a similar way, results of this experiment agreed with the findings [15,16,17,18] which reported that the growth rate and FCR of broilers fed low P diets containing phytase were comparable or even better than those obtained for broilers fed the standard P diets. However, [19] reported that phytase addition to duck diets improved growth and increased feed intake, but not FCR.

The inability of poultry birds to utilize dietary phytate was clearly shown in this study by the significant increase in the final weight, feed intake and body weight gain of broiler chicks fed phytase supplemented diets.

These results agreed with those reported by [20,21,22] which indicated that the body weight gain and feed intake were significantly improved by addition of microbial phytase to broiler diet. On the other hand, the results contradicted the findings of [23], who reported that feed consumption decreased due to addition of enzymes since birds fulfilled their nutrient requirement by taking less amount of feed. The improvement in growth performance of broilers fed phytase supplemented diets could be attributed to the improvement in essential amino acids (including lysine) and metabolizable energy as reported by [24,25,26,27] or due to overall increased utilization of nutrients [28].

Table 3. Effect of phytase supplementation on performance of broilers fed soybean and sesame/soybean based diets

Parameters	Treatments							
	Soybean			Sesame/Soybean				
	T1	T2	T3	T4	T5	T6	SEM	P-Val
Initial weight (g)	162.00	161.00	160.15	160.00	162.80	162.50	1.95	0.685
Final weight (g)	1557.50[e]	1670.00[de]	1767.50[cd]	1862.50[bc]	2212.50[a]	2020.00[b]	56.06	0.000
Weight gain g/day	33.50[d]	37.13[cd]	38.33[c]	40.83[bc]	48.60[a]	44.23[b]	1.30	0.000
Feed intake/day	92.65[b]	93.23[b]	96.95[ab]	96.95[ab]	101.98[a]	97.53[ab]	1.77	0.019
*FCR	2.79[a]	2.52[b]	2.50[b]	2.38[bc]	2.08[d]	2.21[cd]	0.07	0.000

Means with different superscripts in the same row differ significantly (P<0.05)
**Feed Conversion Ratio*
T_1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase
T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase
T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase

The nutrient retention results are shown in Table 4. In soybean meal and sesame/soybean unsupplemented diets, percentage nitrogen retentions were 59.55 and 63.13% respectively. The addition of phytase to soybean meal and sesame/soybean diets significantly increased (P<0.05) nitrogen retention. Phytase addition significantly increased (P<0.05) percentage ash retention while, ether extract and (Fat) retention were not affected (P>0.05) by phytase supplementation. An increased level of crude fiber retention was obtained in diets with supplemented phytase over the control. Similar improvements in nutrient retention obtained in this study as a result of phytase supplementation have been reported in other studies with broiler for apparent nitrogen and phosphorus retention [29]. The addition of microbial phytase to broiler diets often increase apparent digestibility of protein and amino acids as well as enhance the utilization of phytate phosphorus [30]. These results can be explained by the fact that phytase enzyme has a positive influence on gastrointestinal tract digestive enzymes which leads to the increase in digestibility observed in birds fed with P-deficient diets. These results are in agreement with previous findings on broiler [31,32,33,34]. The improvement in nutrient retention was expected because phytase liberates nutrients and minerals from phytate bound mineral complexes.

Phosphorus retention improved as dietary phytase level in the diet increased and the highest P retention was obtained in sesame/soybean based diet (45.58%) with 600FTU/g phytase activity (T 6). Phytase inclusion has been reported to increase minerals (Ca, P) retention and its concentration in serum and tibia ash of broilers by various workers [30,35,36]. Phytate being a strong acid can form various salts with essential minerals, thus reducing their solubility and ultimately their absorption. However, when phytate is hydrolyzed by microbial phytase, it may release all constituent minerals, myo-inositol and inorganic phosphate [37]. Increase in P retention will probably lead to the reduction of the excretion of the mineral into the environment thereby reducing the pollution rate.

Table 4. Effect of phytase supplementation on nutrient utilization by broilers fed soybean and sesame/soybean based diets

Parameters	Treatments							
	Soybean			Sesame/Soybean				
	T1	T2	T3	T4	T5	T6	SEM	P-Val
Nitrogen	59.55^{c}	62.98^{b}	63.64^{b}	63.13^{b}	65.32^{a}	67.22^{a}	2.42	0.038
Ash	68.21^{b}	68.48^{b}	72.48^{ab}	70.36^{ab}	73.65^{a}	74.85^{a}	1.90	0.024
Fat	57.12	60.70	62.90	63.99	65.43	64.75	3.84	0.661
Crude Fiber	64.72^{c}	69.55^{b}	71.76^{b}	68.65^{b}	75.53^{a}	76.22^{a}	2.23	0.044
Phosphorus	28.12^{d}	34.33^{c}	37.12^{b}	29.03^{d}	32.51^{c}	45.58^{a}	4.08	0.0t42

Means with different superscripts in the same row differ significantly (P<0.05)
T_1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase
T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase
T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase

The carcass characteristics of birds fed diets with and without enzymes are presented in Table 5. The breast muscle of birds fed sesame/soybean meal diet supplemented with 300FTU/Kg phytse was significantly heavier than the others (Table 5). Phytase supplementation increased breast muscle accretion. Data obtained from this experiment revealed that chicks fed diets containing Sesame/soybean diet supplemented with phytase has higher breast weight (P<0.05) than those on soybean meal supplemented diets. This might probably be due to the balance of methionine and lysine in sesame/soybean diet and also due to the high energy content of the feeding regime rather than the effect of microbial phytase alone. The result was in line with those of [38] who reported that the breast meat yield increased (P<0.05) with the increase in synthetic lysine and methionine in the diet. Soybean is reported to be high in lysine [2] while Sesame is noted for its high methionine content [1]. The findings in this study are not in isolation as they agreed with the report of [39,40] who reported that the addition of DL-methionine at 0.05% to the basal diet caused higher (P<0.05) percentage of breast meat yield in broiler. However, the findings of this present study contradicted that of [41] who verified that phytase had no effect on breast yield of broilers.

Table 5. Yield of carcass parts of meat type chicken fed phytase supplemented diets (% live weight)

Parameters	Treatments							
	Soybean			Sesame/Soybean				
	T1	T2	T3	T4	T5	T6	SEM	P-Val
Breast	24.18^{c}	24.42^{c}	26.41^{bc}	26.89^{bc}	29.89^{a}	27.74^{b}	1.05	0.038
Thigh	16.77	15.33	16.57	16.25	17.44	15.37	0.77	1.154
Drum stick	15.46	14.75	15.79	14.26	15.12	13.74	0.44	2.981
Back	21.74	22.87	21.13	20.99	20.46	22.89	1.18	0.754
Wing	11.25	12.26	12.40	11.29	11.41	11.64	0.35	2.023

Means along the same row with similar superscripts are not significantly different (P > 0.05).
T_1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase
T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase
T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase

Similar yields for the carcass and its different parts such as thighs, drumsticks and wings were noted between the control and the different enzyme supplemented groups (Table 5) and are in agreement with the findings of [42,43,44,45,46] who reported no apparent effects on carcass yields when enzymes were added. This probably implied that muscle accretion reached a plateau in response to available nutrient at the levels of crude protein and energy in the diets.

The meat characteristics of broiler chickens fed on diets supplemented with or without phytase are presented in Table 6. There was no significant (P>0.05) effect of phytase supplementation on the chilling loss and shear force values. These findings agreed with that of [47] who reported no significant effect of enzyme supplementation on different meat quality attributes such as shear force among others. However, the result was not in consonance with the findings of the above authors on their assertion that enzyme supplementation did not result in any significant effect on different meat quality traits such as cooking loss and water holding capacity.

Table 6. Meat attributes of broilers fed phytase supplemented diets

Parameters**	**Treatments**							
	Soybean			**Sesame/Soybean**				
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**	**P-Val**
Chilling loss (%)	2.38	3.10	2.16	1.95	3.24	2.45	0.84	0.612
Shear Force (Kg/Cm^3)	3.22	3.18	3.50	3.96	3.71	3.84	0.36	0.686
Cooking loss (%)	28.61^b	31.11^{ab}	32.29^{ab}	25.27^c	32.49^{ab}	35.56^a	2.02	0.038
Water Holding Capacity (%)	65.16^a	60.89^b	58.31^{bc}	62.26^{ab}	58.38^{bc}	57.48^c	4.58	0.042

Means along the same row with similar superscripts are not significantly different (P > 0.05).
*** Measurement was the average values for thigh, drumstick and the breast muscles.*
T1 and T4 = Control diets for soybean and sesame/soybean diets with 0 unit of phytase
T2 and T3 = Treatments for soybean meal diets with 300 and 600 units of phytase
T5 and T6 = Treatments for sesame/soybean with 300 and 600 units of phytase

Water holding capacity is defined as the ability of meat to retain its water upon the application of an external force [48] and it is a primary indicator of degree of meat juiciness. Enzyme supplementation negatively affected the WHC as it reduced as the phytase inclusion increased in both feeding regime. Cooking yield of meat is dependent on cooking loss while cooking loss is a function of the WHC. The cooking loss percent obtained in this experiment increased as the enzyme inclusion increased indicating a lower yield for enzyme supplemented group.

4. CONCLUSION

It can therefore be concluded that sesame/soybean diet supplemented with 300 FTU/Kg microbial phytase should be adopted as the feeding regime of choice over the soybean enzyme supplemented diet since this feeding regime resulted in; optimum weight gain and better FCR. Also, the synergistic effect of the combination became pronounced in nutrient utilization especially at level of 600 FTU/Kg. Nitrogen and Phosphorus utilization increased with the implication that less of these nutrients will be excreted to the environment. The effect of phytase supplementation on cooking loss and WHC bears an important implication on poultry processing industry.

ETHICAL APPROVAL

All authors hereby declare that principle of laboratory animal care (nih publication no. 85-23. Revised1985) were followed, as well as specific national laws where applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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