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Nutritional evaluation of breadfruit and beniseed composite flours

Abstract

This study assessed the chemical composition, functional, mineral, and anti-nutritional properties of composite flour produced from breadfruit and beniseed. Matured and freshly harvested breadfruit (Artocarpus altilis) and beniseed (Sesame indicum) were obtained from a local market in Calabar. Three blends were prepared by homogenously mixing breadfruit flour and beniseed flour in the percentage proportions as 70:30 (sample B), 80:20 (sample C), and 90:10 (sample D) while 100% wheat flour (sample A) was used as control. Proximate, functional, mineral, and anti-nutritional properties of the composite flour were examined using standard methods. Results obtained indicated that the chemical composition of the composite flour ranged from 25.40 to 36.23mg/100g moisture, 19.63 to 22.33mg/100g protein, 19.33 to 26.23mg/100g fat, 2.37 to 8.82mg/100g ash, 0.33 to 3.25mg/100g crude fiber, 65.73 to 141.67mg/100g calcium, 62.74 to 138.80mg/100g magnesium, 117.13 to 834.36mg/100g sodium. Residual anti-nutrients in the composite flour ranged from 3.30 to 7.94mg/100g oxalate and 0.26 to 0.79mg/100g phytate. The functional properties of the composite flour ranged from 140.8 to 170.03g/ml water absorption capacity, 0.76 to 4.79g/ml bulk density and 145.0 to 170.10g/ml oil absorption capacity. Sample B (70:30 ratio of breadfruit flour and beniseed flour) showed significant ($P<0.05$) improvement in the chemical composition, functional, and mineral properties of the flour when compared to the other substitution levels and control There was significant ($P<0.05$) reduction of anti-nutrients in sample B compared to the other substitution levels and control. The result has shown that sample B (70:30) composite flour showed improved chemical composition and could be utilized for product development in different food system.

Keywords: breadfruit, beniseed, flour, functional quality

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Abbreviations: MMT, million metric tons; OAC, oil absorption capacity; WAC, water absorption capacity; BD, bulk density; AOAC, association of official analytical chemists

Introduction

In developing nations, numerous of wild edible plants are exploited as food sources; hence they provide an adequate level of nutrition to the inhabitants. Sesame (*Sesamum indicum* L.) belongs to the *Pedaliaceae* family of plants and it is cultivated in several countries including the USA, India, China, Burma, Sudan and Nigeria.[1] The seed is high in edible oil, protein and calcium and has been used as food for ages.[2] In Nigeria, the seeds are fried or used to produce soup for human consumption.[3] Uaboi et al.[4] suggested that fermented sesame seeds could be used as a soup condiment. Sesame has been valued as a healthy food additive preventing diseases and promoting wellbeing. Its nutraceutical uses include cancer prevention (myristic acid), prevention of heart disease. Sesame seed consumption appears to increase plasma gamma-tocopherol and enhanced a vitamin E activity which is believed to prevent cancer and heart disease.[5] In addition sesame seeds contain two unique substance, sesamin and sesamolin which belong to a group of special beneficial fibers called lignans, and have been shown to have a cholesterol lowering effects in humans. It also prevents high blood pressure and increase vitamin E supplies in animals. Sesame has been found to protect the liver from oxidative damage. Sesame seed phytosterols reduce cholesterol, enhance the immune response and decrease risk of certain cancers.

Breadfruit (*Artocarpus altilis*) is a member of the *Moraceae* family and is normally consumed after cooking. It's a rich source of carbohydrates, fiber, vitamin (vitamin C) and mineral (potassium).[3] This plant plays a main function to ensure food safety in the rural communities where they are predominant due to its high carbohydrate content (76.71 to 79.24 %). It has been used as an important source of energy for years. Breadfruits are found from sea level to about 1.550 m elevation. The latitudinal limits are approximately 17°N and 17°S. In Africa, breadfruits are found in some country (Senegal, Guinea-Bissau, Cameroun, Sierra Leone, Nigeria, Liberia and Ghana).[6] However, the current usage, particularly, in developing countries, is limited by the poor fresh fruit storage properties. A few days after harvesting (3days), the deterioration of the fruit settles and because of their high water content they are easily susceptible to microbial attack as well as their bulky nature makes their transportation difficult. It is therefore reasonable to maximize the potential of this precious nutritious fruit by transforming them into various finished products easily storable. This production of flour from breadfruit is a useful technique to extend its storage and consumption. Different conventional flours are important and have precious functional roles in global food systems. However, their increasing price led to the search of other flours less expensive unconventional as an alternative for replacement partially or completely the traditional conventional flours in foods as a means against malnutrition.

Many developing nations spend huge amount of their foreign exchange for the importation of food especially wheat, rice and sugar. For instance, in 2011 Africa spent more than $ 50billion on food imports.[7] Nigeria spends $ 4.2billion yearly for the importation of wheat.[8,9] According to Momoh,[10] in 2010 alone, Nigeria spent N 635billion ($ 4.2billion) on the importation of wheat, N 356 billion on the importation of rice, N 217billion on sugar and N 97billion on fish.

It has been reported that wheat importation is growing at the rate of 13% per annum. It has been estimated that at this growth rate, Nigeria wheat importation could reach 17million metric tons (MMT) by 2020, which is equivalent to the entire wheat production by Canada (the third largest wheat producing country in the World.[11]

The use of composite flours has been reported by many authors. Oloye et al.[12] investigated the use of supplementation of flours of soybean and plantain in wheat in the production of bread. Also, Mepba et al.[13] produced composite breads and biscuits from mixed flours of wheat and plantain, with 30% supplementation of plantain flour. Though breadfruit has been made into flour and evaluated in bakery products not much has been done in the area of composite flour blends of breadfruit and beniseed. Therefore, it becomes pertinent to evaluate the composite flours aiming at reducing wheat flour inflation and curtail excessive losses of breadfruit during season. Hence, the study is aimed at evaluating the proximate, functional, mineral and anti-nutritional properties of breadfruit and beniseed composite flours.

Materials and methods

Sample(s) collection

Matured green ripe and wholesome fruits of breadfruit (*Artocarpus altilis*), beniseed (*Sesame indicum*) and wheat flour (*Triticum aestivum*) were purchased at Marian market, Calabar, Cross River state and taken to the laboratory of the Department of Biochemistry, University of Calabar. The samples were packaged in polyethylene nylon and stored for 24hrs at 4°C before analysis.

Breadfruit flour production

The breadfruits were processed into flour. Breadfruit samples were washed, peeled and sliced manually into 1cm thick slices using stainless steel knife. The washed sliced breadfruit pieces were immediately placed in an oven (Wagtech-Model GP120SSE300HYD) and dried at 70°C for 24hours. The dried chips were milled and sieved through a 0.25mm British standard sieve (Model BS 410). The flour was then packaged in thick gauge (0.04mm) transparent polyethylene nylon and stored at 4°C for 24hrs before analysis.

Beniseed flour production

Beniseed grains were washed three[8] times to remove sand and debris and then allowed to drip dry through a mesh. The washed grains were then oven dried at 70°C for 12hours on aluminum foil and milled with a milling machine to obtain flour which was subsequently sieved to yield a fine flour texture. The flour was then packaged in air tight containers and stored at 4°C for 24hrs before analysis.

Composite flour formulation

Three different flour blends were formulated at different ratios from the breadfruit and beniseed flour using an electronic weighing balance as shown in Table 1. Wheat flour (100%) was used as the standard or control (A), making 4 different flour blends. The blend proportions were: 700g of breadfruit flour to 300g of beniseed flour (70:30 blends (B)); 800g of breadfruit flour to 200g of beniseed flour (80:20 blends (C)); 900g of breadfruit flour to 100g of beniseed flour (90:10 blends (D)) and then 1000g of pure wheat flour. Each blend proportion was thoroughly mixed together using a blender (model no 1131) to get an even blend and then kept in air tight plastic containers at room temperature for 24hrs.

Table 1 Formulation of blend proportion of breadfruit and beniseed flours

Blend proportion	Breadfruit flour	Beniseed flour	Wheat flour
A	-	-	100
B	70	30	-
C	80	20	-
D	90	10	-

A=100% of Wheat flour (Control)

B=70% Breadfruit flour+30% Beniseed flour

C=80% Breadfruit flour+20% Beniseed flour

D=90% Breadfruit flour+10% Beniseed flour

Bulk density (BD)

The method described by Oladele et al.[14] was used for the determination of bulk density. Fifty grams (50g) of the sample pulp flour was put into 100ml measuring cylinder. The measuring cylinder was then tapped continuously on a laboratory table until a constant volume was obtained. BD (g/ml) was calculated using following the formula:

$$BD\ (g/ml) = \frac{weight\ of\ the\ sample}{volume\ of\ sample}$$

Oil absorption capacity (OAC)

The oil absorption capacity (OAC) of flours was evaluated according to Eke et al.[15] method. One gram (1g) of sample was mixed with 10 ml of refined groundnut oil. The slurry was agitated on a Vortex mixer for 2min and allowed to stand at 28˚C for 30min. After 30min standing, the suspension was centrifuged at 300rpm for 25min. Volume of free oil was measured. Oil absorption capacity was expressed as the amount of oil (in ml) absorbed by a gram of flour sample.

Water absorption capacity (WAC)

The water absorption capacity of the flours was evaluated according to Anderson et al.[16] method. One gram (1g) of flour samples was each weighed into a centrifuge tube and 10ml distilled water added. The content of the centrifuge tube was shaken for 30min in a KS 10 agitator. The mixture was kept in a water bath (MEMMERT) (37˚C) for 30min and centrifuged (ALRESA, DITACEN II) at 5000rpm for 15min. The resulting sediment (M_2) was weighed and then dried at 105˚C to constant weight (M_1). The WAC calculated as follows:

$$WAC\ (\%) = \frac{M_2 - M_1}{M_1} \times 100$$

Mineral analyses

Calcium (Ca), Magnesium (Mg), Sodium (Na) and Phosphorus

(P) was determined according to AOAC.[16] Sample weighing 10g was transferred into a crucible, and heated over flame to volatile as much of the organic matter as possible, before transferring into a muffle furnance to burn at 450˚C for 5-7hrs. To the ash was added 10ml of dilute HCl, boiled for a few minutes, and made up to 100ml with distilled water. This was then used for the mineral analysis as described in AOAC.[17,18]

Proximate analyses

Moisture, protein, crude fat, crude fibre, ash content was determined by the method of the Association of Official Analytical Chemists'.[17,18]

Anti-nutritional analyses

Oxalate content of the flour samples was determined using the method of Day et al.[19] One gram of the sample was dissolved in 100ml of 0.75M H_2SO_4. The solution was then carefully stirred with a magnetic stirrer for 1hr and filtered. Twenty five milliliter (25ml) of the filtrate was pipette and titrated hot (85˚C) against 0.1M $KMNO_4$ to end point of a faint pink colour that persisted for more than 30seconds. It was calculated as:

T×constant

Phytate content of the flour samples was determined by the method of Nkama et al.[20] Four grams (4g) of the sample was soaked in 100ml of 2% HCl for 3hrs and then filtered. Five milliliter (5ml) of 0.3% ammonia thiocynate (NH_4SCN) solution was added to 25ml of the filtrate. Fifty three milliliter (53ml) of distilled water was also added to the mixture. This was then titrated against a standard iron (III) chloride ($FeCl_3$) solution until a brownish yellow colour persisted for 5min. The phytate content was calculated as:

T×constant

Statistical analyses

All analyses were carried out in triplicate. Data were analyzed using a one-way analysis of variance (ANOVA). Mean separation was done by the Duncan's multiple range test using the Statistical Package for the Social Sciences (SPSS) version 13.0 (Chicago, U.S.A). Differences were considered statistically significance at P<0.05.

Results

Proximate composition

The result of proximate composition of breadfruit and beniseed composition flour blends are shown in Table 2. The result of the moisture content shows that sample D was the highest with a value of 36.23±1.16, which was significantly (P<0.05) higher than sample A (28.93±1.09) and sample B (25.40±0.56). The protein content of sample B had a value of 22.33±0.11, which was significantly (P<0.05) higher than sample A (19.63±0.88). Sample C had a value of 21.44±0.00, which was significantly (P<0.05) higher than sample A and significantly (P<0.05) lower than sample B and sample C respectively. The fat content of sample B was the highest with a value of 26.63±0.88, which was significantly (P<0.05) higher than sample A (19.33±0.88).

Sample C (24.66±0.88) was significantly (P<0.05) higher than sample A and significantly (P<0.05) lower than sample B. The sample D (20.36±0.14) was significantly (P<0.05) higher than sample A and significantly (P<0.05) lower than sample B. Sample B showed the highest ash content (8.82±0.15) which was significantly (P<0.05) higher than sample A (4.26±0.12), sample C (2.26±0.88) and sample D (3.01±0.00). Sample D was significantly (P<0.05) higher than sample C. The crude fibre content showed that sample B had a value of 3.24±0.08 which was significantly (P<0.05) higher than sample A (0.33±0.05), sample C (2.70±0.10) and sample (3.17±0.06). Sample D was significantly (P<0.05) higher than sample A and C.

Functional properties

The result of the functional properties of composite flour of breadfruit and beniseed are shown in Table 3. The water absorption capacity for sample D had a value of 170.1±0.03 which was significantly (P<0.05) higher than sample A (140.8±0.03) and significantly (P<0.05) lower than sample C (159.1±0.03) and sample B (152.1±0.03). The bulk density of sample B had a value of 2.90±0.00 which was significantly (P<0.05) different from sample A (0.76±0.01), sample C (3.50±0.10) and sample D (4.96±0.10). The oil absorption capacity of sample B (170.1±0.10) was higher than sample C (166.1±0.10) and sample D (163±0.10) was not significantly (P>0.05) different from each other.

Table 2 Proximate composition of breadfruit/beniseed composite flour

Sample	Moisture (mg/100g)	Protein (mg/100g)	Fat (mg/100g)	Ash (mg/100g)	Crude Fibre (mg/100g)
A	28.93±1.09	19.63±0.09	19.33±0.09	4.27±0.12	0.33±0.03
B	25.40±0.57	22.33±0.01*	26.63±0.09*	8.82±0.02*	3.25±0.05*
C	26.17±2.48	21.44±0.01*	24.67±0.09*,a	2.37±0.09*,a	2.70±0.06*
D	36.23±1.17*,a	20.04±0.15*,a,b	20.37±0.15*,a	3.01±0.01*,a,b	3.18±0.04*

Values are expressed as Mean±Standard Deviation, n=3

*=P<0.05 Vs sample A; a=P<0.05 Vs sample B; b=P <0.05 Vs sample C

A=100% of Wheat flour (Control)

B=70% Breadfruit flour+30% Beniseed flour

C=80% Breadfruit flour+20% Beniseed flour

D=90% Breadfruit flour+10% Beniseed flour

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Table 3 Functional properties of breadfruit/beniseed composite flour

Sample	WAC (g/ml)	BD (g/ml)	OAC (g/ml)
A	140.8±0.03	0.76±0.01	145.0±08.10
B	152.10±0.03	2.90±0.00	170.10±0.10[*,a,c]
C	159.10±0.03	3.50±0.10	166.10±0.10[*,a]
D	170.10±0.03	4.79±0.10	163.5±0.10[a]

Values are expressed as Mean±Standard Deviation, n=3S

Samples are significantly different from each other (P<0.05), Except for those marked *,a,c which shows insignificant difference from A, B and C.

A=100% of Wheat flour (Control)

B=70% Breadfruit flour+30% Beniseed flour

C=80% Breadfruit flour+20% Beniseed flour

D=90% Breadfruit flour+10% Beniseed flour

Mineral composition

The result of the mineral composition of the composite flour blend of breadfruit and beniseed are shown in Table 4. The calcium content of sample D had a value of 65.73±0.05 which was significantly (P<0.05) lower than sample C (67.81±0.01) and sample B (68.4±0.43) but significantly (P<0.05) higher than sample A (141.7±0.36). The magnesium content shows that sample B had a value of 71.70±0.61 which was significantly (P<0.05) higher than sample A (138.80±2.58) and significantly (P<0.05) higher than sample C (65.01±0.01) and sample D (62.74±0.03). The sodium content of sample B had a value of 130.44±0.58 which was significantly (P<0.05) lower than sample A (834.36±7.37), and higher than sample C (125.0±0.01) and sample D (117.13±0.02).

Table 4 Mineral content of breadfruit/beniseed composite flour

Sample	Calcium (mg/100g)	Magnesium (mg/100g)	Sodium (mg/100g)
A	141.67±1.73	138.80±2.58	834.36±7.37
B	68.40±0.05	71.70±0.03	130.44±0.58
C	67.81±0.01	65.01±0.01	125.0±0.01
D	65.73±0.43	62.74±0.61	117.13±0.02

Values are expressed as Mean±Standard Deviation, n=3

Samples are significantly different from each other (P<0.05).

A=100% of Wheat flour (Control)

B=70% Breadfruit flour+30% Beniseed flour

C=80% Breadfruit flour+20% Beniseed flour

D=90% Breadfruit flour+10% Beniseed flour

Anti-nutritional Properties

The results of anti-nutritional analysis are shown in Table 5. Sample D showed the highest level in oxalate content. It has a value of 7.94±0.01 which was significantly (P<0.05) higher than sample A (3.30±0.12), sample C (5.47±0.09) and sample B (3.52±0.01). The phytate content showed that sample B (0.26±0.00) and sample C (0.28±0.00) had values which was significantly (P<0.05) lower than sample A. Sample D (0.30±0.00) was significantly (P<0.05) lower than sample A and significantly (P<0.05) higher than sample B and C.

Table 5 Anti-nutritional properties of breadfruit/beniseed composite flour

Sample	Oxalate (mg/100g)	Phytate (mg/100g)
A	3.30±0.12	0.79±0.01
B	3.52±0.02[*]	0.28±0.00[*]
C	5.47±0.09[*,a]	0.26±0.01[*]
D	7.94±0.02[a,b]	0.31±0.01[*,a,b]

Values are expressed as Mean±Standard Deviation, n=3

*= P<0.05 vs sample A; a=P<0.05 vs sample B; b=P<0.05 vs sample C

A=100% of Wheat flour (Control)

B=70% Breadfruit flour+30% Beniseed flour

C=80% Breadfruit flour+20% Beniseed flour

D=90% Breadfruit flour+10% Beniseed flour

Discussion

Proximate composition

The moisture content of the composite flour blends significantly (P<0.05) increased from 25.40±0.98% to 36.23±2.02% with increase in the level of breadfruit flour (70-90%). The increase in moisture content could be due to blend proportion and interaction. Moisture and water activity of the product determine greatly the keeping quality of the foods. The protein content increases with increase in the level of beniseed flour (10-30%) substitution. The values ranged from 20.04±0.25% to 22.33±0.02%. At 30% substitution level, the composite flour had the highest protein. It was observed that the protein value for sample B was higher than sample A. This increase is obviously due to increase in the proportion of beniseed. Alobo[21] reported that beniseed has a good balance of amino acids with a chemical score of 62% and a net protein utilization of 54% protein is an important component that determines the rheological properties of composite flours. Hence, this indicates that baked products from sample B may supply significant amount of protein to the body. The fat content of the flour blends increase with increment in substitution levels of beniseed. This may be attributed to the addition of beniseed flour, which is an oil seed. Sample B showed higher fat content compared to the other samples. Fat plays a significant role in the shelf life of food products and as such relatively high fat content could be undesirable in baked food products. This is because fat can promote rancidity in foods, leading to development of unpleasant and odourous compounds.[22] The Ash content of sample B was significantly (P<0.05) higher compared to other samples. The values ranged from 3.01±0.01% to 8.82±0.02%. This suggests that the composite flour is high in minerals. This is in agreement with report by Ragone.[23] The fibre content increases with increase in the level of beniseed flour. The values ranged from 31.17±0.06% to 3.24±0.08%. It was observed that sample B had significantly (P<0.05) the highest values, while the least crude fiber value was sample A. High fiber is beneficial as it contributes to the health of gastro-intestinal system and metabolic system in man.

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Functional properties

The functional properties are the intrinsic physicochemical characteristics which may affect the behaviour of food systems during processing and storage. Water absorption capacity (WAC) is defined as the differences in the flour weight before and after its water absorption. It's also the ability to absorb or retain water. This ability is a very important property of all flours in food preparations. Besides, water absorption capacity is an index of the maximum amount of water that flour can absorb or retain. The water absorption capacity of the samples increased progressively with increase in breadfruit substitution levels but decrease in beniseed substitution levels. Similar results were reported by Eke et al.,[15] who showed increased water absorption values in flours from African yam bean and jackfruit when heat processing was applied. Aboubakar et al.[24] suggested that the non-starch component of the flours contribute highly to their water absorption. The ability of food to absorb water may be sometimes attributed to its proteins content.[25] The denatured proteins in flour due to heat processing bind more water and hence could lead to flour with higher water absorption. Furthermore, water absorption capacity of flours is a useful indicator of whether protein could be incorporated with the aqueous food formulations, especially, those involving dough handing. Based on the results, sample B showed lower levels of water absorption capacity when compared to sample C and sample D. The lower water absorption capacity of sample B confirms the low charge density and relative hydrophobicity of the sample protein that gives it a tendency to interact. Therefore sample B could be more useful as functional ingredient in viscous food, like baked products to increase viscosity Bulk density is defined as the ratio of flour weight to volume in gram per milliliter or centimeter cube (g/ml or g/cm^3).[26] Bulk density (BD) is a measure of flour heaviness and an important parameter that determines the suitability of flours for the ease particulate foods packaging and transportation.[27] The bulk density increase with increased in the amount of breadfruit substitution levels. This high bulk density in the composite flour might be attributed to high fiber content in the flours. High bulk density serves as a determinant in packaging, raw material handling and application in the food industry.[27] Sample B recorded the least levels of bulk density when compared to sample C and sample D. The reduced bulk density level in sample B could implies that less quantity of the food samples could be packaged in constant volume ensuring an economical packaging. It nutritionally promotes well digestibility especially among children who have immature digestive system diseases. Thus, it could be a good candidate for children food. Oil absorption capacity (OAC) is defined as the difference in the flour weight before and after its oil absorption.[28] It is great importance, since fat acts as flavor retainer and also increases soft texture to mouth feel of foods, especially bread and other baked foods.[29] They are also important because of their storage stability and particularly in the rancidity development. The oil absorption capacity increase with increased in beniseed substitution levels. Sample B showed higher level of oil absorption capacity.

Mineral elements

The mineral contents of the composite flours were significantly ($P<0.05$) improved. Understandably, the higher mineral contents of the experimental samples could be attributed to the increasing proportions of beniseed, which contains high mineral elements. Mineral elements play vital role in metabolic processes. This includes regulation of muscle contractions, transmitting of impulses, bone formation, maintenance of osmotic pressure, acid-base balance, absorption of glucose among others. Sample B recorded higher levels of mineral elements for calcium, magnesium, and sodium when compared to sample C and sample D. Weaver et al.[30] reported that calcium is a micronutrient essential to health & well being, which performs diverse biological function in the human body. It serves as a second messenger for nearly every biological process, stabilizes many protein and in deficient amounts is associated with a large number of disease.

Anti-nutritional properties

There was significant ($P<0.05$) differences in the levels of oxalate. Oxalate content in the samples ranged from 3.52±0.03mg/100g to 7.94±0.03mg/100g. It was observed that the oxalate content decreases with decrease in the level of breadfruit flour substitution (90-70%). This decrease could be attributed to nutrient-nutrient interaction with decreasing levels of breadfruit. Consumption of high levels of oxalate causes low plasma calcium, corrosive gastroenteritis, renal damage, and shock.[31] Sample B showed the least level of oxalate content. The level of phytate content decreases with decreased in the level of breadfruit flour substitution. The reduction may be due to nutrient-nutrient interaction with decreasing breadfruit levels. Sample B showed the least level of phytate. High levels of phytate in human nutrition limit bioavailability of minerals by formation of insoluble compound with the mineral.[32–34] The values observed in this study may be low as to have anti-effect to the nutrients. Generally, the result showed that the levels of anti-nutrient in the composite flour blends were below toxic levels.

Conclusion

The results obtained from this study have demonstrated the potential of composite flour blends of breadfruit (*Artocarpus altilis*) and beniseed (*Sesame indicum*). The composite flour of sample B (70% breadfruit flour and 30% beniseed flour) had improved chemical, functional, and mineral composition. Thus, could be utilized for product development in different food system.

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Conflict of interest

The author declares no conflict of interest.

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