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# Composting of Waste Fruit Bunches with Coir Pith and Animal Manure

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## ABSTRACT

The aerobic composting of empty fruit bunches, coir, and a minimal amount of manure is the subject of an experimental investigation carried out in a tank that matches the dimensions of a laboratory. Fruit bunches typically include a high concentration of carbon (C), nitrogen (N), potassium (K), fibre, and phosphorus (P), all of which contribute to the fertility of the soil and encourage the growth of plants that can flourish. One of the most significant benefits of using coir is that it can effectively absorb leachate during composting. During the previous research, experiments were carried out with two different kinds of inoculum: chicken manure and cow dung. This study uses an experimental technique for in-vessel composting, with sheep dung serving as the input. An analysis of the C: N ratio, pH, temperature, and moisture content was performed every three days throughout the entire composting cycle, which lasted for 28 days. The compost was partially mixed into the soil to examine the development of plants.

**Keywords:** In-vessel aerobic composting; Empty fruit bunches; Cow dung; Chicken manure; Raw coir pith.

## 1. INTRODUCTION

Composting is the term used to describe the biological degradation and stabilization of organic materials. The primary outputs of composting systems include thermal energy, carbon dioxide, water, and nitric oxide (Azizul *et al.* 2010). These components are created using biodegradable elements in the composting procedure. Upon maturation, the final product possesses stability and can be directly applied to soil to enhance its physical, chemical, and biological characteristics (Arutchelvan *et al.* 2009). For the efficient composting of biological wastes, it is crucial to consider factors such as nutrients, heavy metals, temperature, aeration rates, effective microorganisms (EM) (Keumjoo, 2011), smell generation, and the cost of composting. Keumjoo (2011) identified ammonia release as a significant obstacle in aerobic composting of biological wastes. This occurs when materials with a low carbon-to-nitrogen ratio are composted.

The use of EM to initiate the composting process can potentially reduce the amount of time required for the composting process (Misra *et al.* 2003; Lee and Cho, 2010). The research done by (Faure and Deschamps, 1991) did not produce evidence that could be considered definitive on the effectiveness of electromagnetic technology in speeding up the composting process. Using inoculated effective microorganisms in conjunction with the co-composting of food waste and animal manure was proposed as a viable solution to the problems associated with managing food waste and animal manure (Abbasi and Gajalakshmi, 2008). The incorporation of EM had no positive effects on composting organic wastes. (Mupondi *et al.* 2006) found that inoculation with EM did not affect the properties of feedstock materials, such as pH, electrical conductivity (EC), and the C/N ratio.

The use of unstable composts has the potential to slow plant growth, damage crops through oxygen competition, and cause phytotoxicity in plants due to insufficient organic matter biodegradation (Keeling *et al.* 1994). The effective use of composts in agriculture is greatly affected by their stability and maturity (Mathur *et al.* 1993). It is well-known among compost producers and consumers that there are several methods for determining the maturity stage of compost (Inbar *et al.* 1990). Stability and maturity are the foci of these approaches. Stability in respiration is tested by measuring oxygen uptake. A seed germination test might be used for the maturity evaluation (Epstein, 1997). As a result, this research intends to introduce the EM system as an inoculant and evaluate the stabilizing powers of composting food waste and co-composting food waste with chicken manure (Alamgir *et al.* 2012).

According to certain estimates, around 68 million tonnes of fruit was produced in India in 2013. On the other hand, more than 30% of this quantity is lost due to factors such as inefficiencies in the fruit market and practices at juice centres (Chun *et al.* 2012). A considerable percentage of this rubbish is disposed of in landfills, which are dump sites that produce vast amounts of odour and decomposition, resulting in a substantial quantity of leachate. In addition to landfilling and incineration, there are several other waste reduction solutions accessible here (Behera, 2006). As a result of the disposal of these wastes, environmental crises occur. These crises include air contamination through the release of greenhouse gases, volatile organic compounds, and other toxic gases; the pollution of water (surface water and groundwater) caused by leachate production from landfills; and pollution of land caused by the dumping of waste into landfills. Composting is a microbiological process involving transforming biodegradable organic matter into manure (Bouchra *et al.* 2010). This process effectively minimizes the amount of waste production. It regulates water pollution, both in groundwater and surface water, to maintain the quality of the soil and the land. Lab-scale in-vessel composting is one of the many ways of composting. It is a small-scale arrangement investigating substrate transformation into compounds similar to humus (Gnanakumar *et al*. 2014). To achieve optimal compost production, it is essential to carefully regulate the amount of moisture present and provide enough aeration.

**Table 1. Weight and C/N ratios of compost**

| Trial No. | Initial Weight (Kg) | Final Weight (Kg) | C/N Ratio (initial) | C/N Ratio (final) |
|---|---|---|---|---|
| 1. | 3 | 1.25 | 32.60 | 16.53 |
| 2. | 3 | 1.5 | 22.6 | 17.81 |

**Table 2. Typical solid waste compost mixture**

| S. No. | Parameters | Standard Range |
|---|---|---|
| 1. | Moisture (%) | 40 – 60 |
| 2. | Temperature (°C ) | 45 – 65 |
| 3. | Oxygen (%) | >5 |
| 4. | pH | 5.5 – 8.5 |
| 5. | Organic matter (%) | >20 |
| 6. | Organic carbon (%) | 30 – 40 |
| 7. | C:N ratio | 25 -30:1 |

## 2. MATERIALS AND METHODS

### 2.1 Feedstocks and Their Ratios

The study consisted of two tests, T1 and T2, each executed with a unique combination ratio of 60:30:10 feedstock and manure, bulking agent, and initial culture, which is as follows:

T1 – combination of waste fruit bunches + chicken wastes + coir pith

T2 – combination of waste fruit bunches + sheep wastes + coir pith

### 2.2 Reactor Setup

The composting reactor is a simple cylindrical structure made of acrylic fiber with the following dimensions: The capacity of the container is 15.88 L, and its diameter is 300 mm. The feedstock was placed above the stainless-steel grid, positioned 90 mm away from the reactor’s base. The g rid had a mesh size of 8 mm, with each opening forming a square shape.

The fan used to aerate the feed material was an electric device with 12 inches (30.5 cm) dimensions. Fig. 1 is a schematic representation of an aerobic vessel used in the study. Fig. 2 depicts the actual set-up for T1 trial. Fig. 3 shows Trial 2 blend.

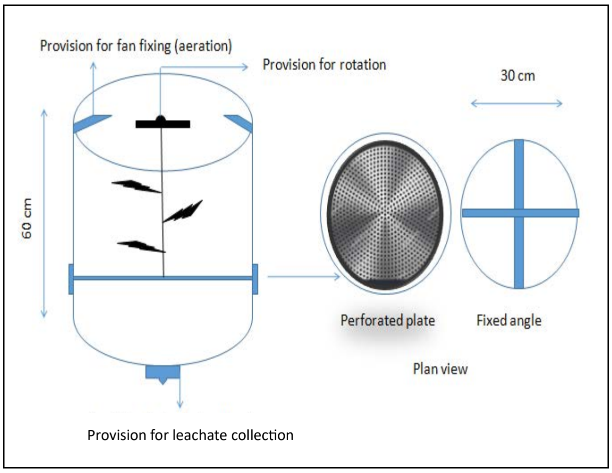


**Fig. 1: Schematic representation of an aerobic vessel**

**Fig. 2: Experimental setup for trial 1**

### 2.3 Experimental Procedure

The study involved conducting two sets of experiments to develop fertilizers using different combinations of organic waste materials. The goal was to evaluate the effectiveness of these combinations for plant growth and overall yield. The process followed several steps, from the initial preparation of ingredients to the final fertilizer collection. The primary ingredients used for the study were waste fruit bunches, animal wastes (either chicken or sheep) (Ferreira *et al*. 2009), and coir pith. These materials were carefully measured and stored according to predetermined ratios. For each experiment, the blends were made up of:

T1: A combination of waste fruit bunches, chicken wastes, and coir pith. T2: A combination of waste fruit bunches, sheep wastes, and coir pith.

**Table 3. Biodegradation levels of trial 1**

| Parameter | Days | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 | 28 |
| pH | 4.39 | 4.42 | 4.78 | 4.93 | 5.31 | 5.50 | 5.82 | 6.11 | 6.25 | 6.87 |
| Moisture content (%) | 60.19 | 59.93 | 56.80 | 54.65 | 52.54 | 49.39 | 46.27 | 42.13 | 40.49 | 37.99 |
| Dry matter (%) | 39.81 | 41.07 | 43.21 | 45.35 | 47.46 | 50.61 | 53.73 | 57.82 | 59.51 | 62.01 |
| Organic matter (%) | 78.82 | 75.41 | 72.49 | 69.73 | 65.43 | 61.62 | 58.11 | 46.50 | 39.72 | 35.59 |
| Organic carbon (%) | 46.29 | 43.74 | 41.99 | 40.49 | 37.95 | 35.74 | 33.70 | 26.97 | 23.03 | 20.52 |

**Table 4. Biodegradation levels of trial 2**

| Parameter | Days | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 4 | 7 | 10 | 13 | 16 | 19 | 22 | 25 |
| pH | 7.90 | 7.67 | 7.54 | 7.33 | 7.21 | 7.15 | 7.08 | 6.89 | 6.59 |
| Moisture content (%) | 45.50 | 43.39 | 41.23 | 39.98 | 37.42 | 36.75 | 34.37 | 33.49 | 30.45 |
| Dry matter (%) | 54.50 | 56.61 | 58.77 | 60.02 | 62.58 | 63.25 | 65.63 | 66.51 | 69.55 |
| Organic matter (%) | 65.33 | 64.10 | 61.22 | 58.64 | 54.13 | 51.82 | 48.72 | 47.93 | 45.20 |
| Organic carbon (%) | 38.05 | 37.18 | 35.51 | 34.01 | 31.39 | 30.10 | 28.25 | 27.80 | 26.21 |

A sample weighing roughly 20 g was taken to conduct preliminary tests on moisture content, pH, (Kubota *et al.* 1993) and organic matter. Water was added as needed, depending on the initial moisture content. The same approach was repeated in the succeeding experiments. The two trials are presented in Table 1, which showcases the initial and final weight and C/N ratio. The chemical composition of a regular compost is shown in Table 2.

Once the ingredients were weighed, they were spread out on a large and clean polythene sheet laid on the ground. Mixing was done manually to ensure that all the materials were evenly combined, resulting in a uniform mixture. Proper mixing is essential because it ensures that all the nutrients are distributed throughout the material, contributing to consistent quality in the final product.

For T1, the blend of waste fruit bunches, chicken waste, and coir pith was placed in an acrylic open cylinder that helped in maintaining a controlled environment. The process took place at room temperature while ensuring efficient air circulation throughout the system. An exhaust fan was used to promote water evaporation from the mixture. This evaporation process was necessary for reducing the moisture in raw organic materials to make stable and usable fertilizer. An outlet was provided in the design of the system to collect excess water and this water was discarded every week.

For T2, the procedure was similar, but the blend used consisted of waste fruit bunches, sheep wastes, and coir pith. This mixture was also placed in an acrylic open cylinder and subjected to the same water evaporation process. The exhaust fan ensured proper air circulation, which helped the moisture in the mixture to evaporate at room temperature.

Over time, the mixtures inside the acrylic cylinders in both T1 and T2 began to dry and decompose, transforming into a stable, powdered form of fertilizer. The evaporation process allowed for the moisture content to decrease gradually, leaving behind nutrient-rich fertilizers in both setups. Once the process was complete, the dried powder from both T1 and T2 was collected.

The powdered fertilizers from T1 and T2 were then applied to plants to test their effectiveness. Throughout the experiment, researchers conducted an yield analysis to measure the response of plants to each type of fertilizer (Tiamiyu *et al*. 2012) in terms of growth rate, health, and productivity (quantity of crop yield produced). Comparing the results of the two treatments helped assess the impact of using chicken wastes versus sheep wastes as part of the fertilizer formulation.

**Fig. 3: Blend of fruit bunch waste, sheep waste and coir pith for trial 2**

## 2.4 Analytical Methods

Before composting, the waste underwent analysis to assess (Farah *et al*. 2023) its dry matter, moisture content, organic matter, total nitrogen, total organic carbon, and pH levels. After each complete mixing, a sample weighing roughly 20 g was removed from the reactor and promptly examined. The pH of the deionized water extract was measured using a pH meter. The extract was prepared by mixing it with deionized water in a weight ratio of 1:2. The mixture was then stirred for 30 minutes.

The dry and organic matter of duplicate samples was determined by subjecting them to temperatures of 1050 °C for 24 hours in an oven. Following the drying process in the oven, the sample was filtered using a sieve with a 0.2 mm aperture before being introduced into the muffle furnace, where organic matter is subjected to 5500 °C for 4 hours. The loss-on-ignition method was employed to assess the extent of degradation of organic matter and organic carbon. The NPK values of the final composts were determined using the APHA 22nd Edition 4500 N, APHA 22nd Edition 4500 P (D), and APHA 22nd Edition 4500 K (B) methods, respectively. The ash content of the compost sample was determined by subjecting it to a temperature of 5550 °C for one hour.

## 2.5 Biodegradation Rates of Food Waste

The changes in control parameters, such as pH, moisture content, and organic matter decomposition over time for each experiment were determined (Mathava *et al.* 2010). Analyses of the decomposition process are conducted by examining sequential data for features such as the breakdown of organic matter, reduction of organic carbon, and quantity of ash present. Based on the findings, it has been determined that the organic waste may be composted and stabilized (Namasiku and Oagile, 2010).

# 3. RESULTS AND DISCUSSION

## 3.1 Variation of pH

The pH of a substance, such as soil or compost, is the measurement of its acidity (or alkalinity) or the concentration of hydrogen ions when expressed on a logarithmic scale. A pH scale ranging from 0 to 14 is used, where a value of 7 corresponds to a pH inside the neutral range. A change in pH by one unit signifies a tenfold increase or reduction in acidity. Typically, the pH level of compost ranges from 6 to 87. The initial pH of both experiments was 4.39 and 7.9 (Tables 3 and 4). However, by the second and third days of the experiment, the pH had increased to a range of 6. Fig. 4 shows that the pH reached a value of 6.87 in Trial 1 and 6.59 in Trial 2 by the $28^{th}$ day of the experiment.

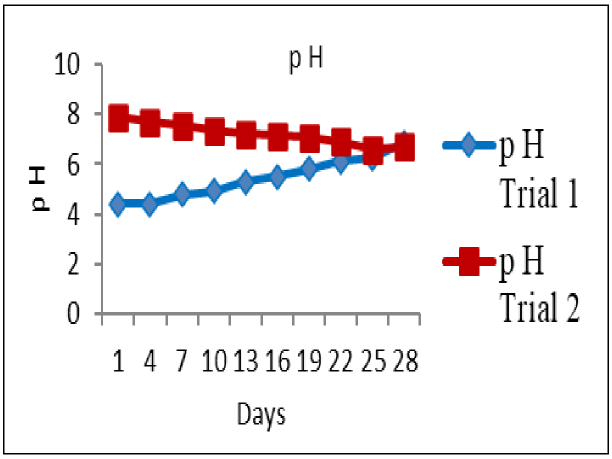


**Fig. 4: pH profile over time from trials 1 and 2**

## 3.2 Variation of Moisture Content

The term "moisture content" denotes the proportion of water within the compost, expressed as a percentage of the compost's total weight. The variability of compost's bulk density, influenced by its moisture content, might impact the handling and transportation processes. A compost with a moisture level ranging from 55 to 60% would have a dense and lumpy consistency, making it challenging to apply and increasing delivery expenses. Conversely, composts with excessive dryness (less than or equal to 35%) would exhibit a high level of powdery consistency and provide challenges in terms of application. The optimal moisture content of mature compost should range from 40 - 50%. Initially, the moisture content of Trial 1 and Trial 2 was 60.19% and 45.05%, respectively. The decrease in moisture content primarily relies on aeration and ranges from 40 -70% until the 20th day. This was mainly due to the process of hydrating the input material. Finally, the percentages gradually decreased to 37.99% and 30.45%, respectively. Fig. 5 depicts the correlation between duration and moisture content, which shows a systematic decrease in the moisture content over time.

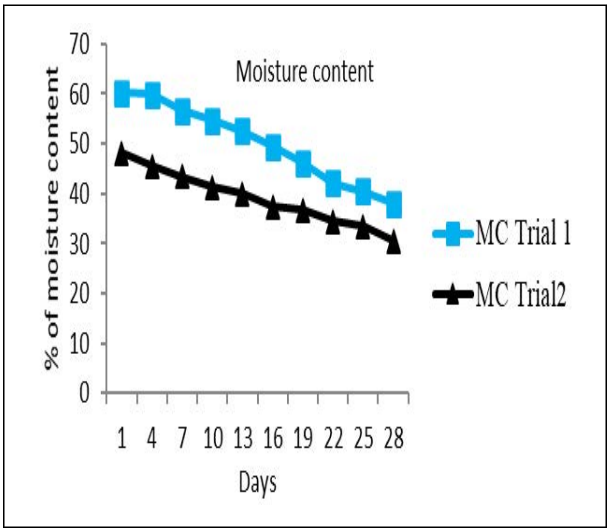


**Fig. 5: Moisture content profile over time from trials 1 and 2**

### 3.3 Variation of Organic Matter

Compost is characterized by its organic matter content, which refers to the number of carbon-based components in the compost. The value is expressed as a percentage relative to the weight of the material when it is entirely free of moisture. It plays a crucial role in soil composition, as well as in its ability to retain water, the availability of nutrients, and the overall structure of the soil. It is a fundamental component found in all types of soil. The nutrient values of the soil used in the study are shown in Table 5.

**Table 5. Nutrient value of soil used as per TNAU**

| Parameter | Value | Unit | Comments |
|---|---|---|---|
| pH | 9.50 | - | Alkaline |
| Electrical Conductivity | 0.06 | ds/m | Non Saline |
| Available Nitrogen | 97 | % | Low |
| Available Phosphorous | 5 | % | Low |
| Available Potassium | 81 | % | Low |

By assessing the amount of organic matter in the compost, one may estimate its physical characteristics and degree of maturity. The organic matter content in compost may be crucial in deciding the application rates for agricultural crop productivity and grass improvement. The permissible application rates of organic matter to the soils are established using test kits. The application rates are specified based on the amount of organic matter needed per acre. Therefore, it is necessary to determine the organic matter content of the compost to determine the allowable application rate in terms of tonnes per acre.

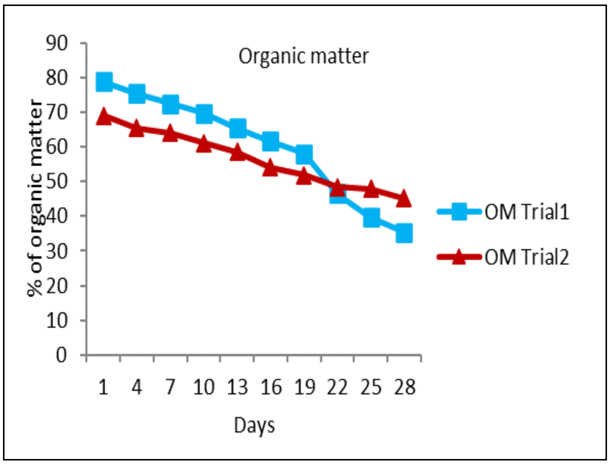


**Fig. 6: Organic matter profile over 28 days for trials 1 and 2**

The organic matter level might vary between 30% and 70%. Food waste often consists of abundant organic material that bacteria can decompose, leading to mineralization. Composting involves the conversion of organic waste into stable compounds that possess the qualities of humus materials. These products are derived from the mineralization and humification processes during the procedure. Furthermore, the process also generates additional metabolic by-products, such as volatile organic molecules, inorganic elements, and biomass. In this investigation, the initial organic matter content in two trials was 78.82% and 65.33%, respectively. Over time, the organic matter content gradually decreased due to microbial activity, reaching approximately 35.59% and 45.2% after 28 days of study, as shown in Fig. 6.

**Fig. 7: Plant growth in average soil**

**Table 6. NPK values for compost**

| Trial | N (%) | P (%) | K (%) |
|---|---|---|---|
| 1 | 1.24 | 0.18 | 0.81 |
| 2 | 0.98 | 0.33 | 1.11 |

### 3.4 Effect of Plant Growth and its Yield

The NPK values of the soil used and the outcomes of two compost experiments are provided in Tables 6 and 7, respectively. We did a comparison study to detect the disparities in the abovementioned criteria. Seeds of Solanum melongena (brinjal), Capsicum annum (chilli), and Citrullus lanatus (watermelon) were sown in four separate containers. One seed was planted in standard soil, while the other two were placed in soils mixed with the final compost, which weighed 500 g—obtained from each of the three trials in their respective sequence.

**Fig. 8: Plant growth for soil mixed with trial 1 compost**

The seeds planted in soil coupled with Trial 2 compost had a greater yield, possibly attributable to its increased NPK value. Similar outcomes were achieved in the remaining experiments, contingent upon the NPK value of those trials. The sequence consisted of three figures: Fig. 7 represents regular average soil. Fig. 8 shows plants grown in soil combined with Trial 1 compost, and Fig. 9 represents plants grown in soil mixed with Trial 2 compost.

### 3.5 Comparison of Results

The factors mentioned above exhibited a 5 to 10% variance throughout all three studies, yielding nearly identical outcomes. Both tests indicated a pH of 7, classified as almost neutral. Regarding the moisture content, the first and second trials exhibited the prescribed range of thirty to forty percent, while the first trial had a slightly elevated percentage level. The highest levels of organic matter and organic carbon reduction were achieved in the first and second trials. The ideal range for the quantity of organic matter in compost is not fixed; it might vary between 30-70%.

**Fig. 9: Plant growth for soil mixed with trial 2 compost**

**Table 7. Plant growth and yield studies**

| Trial | Germination observed | Stem height (cm) | | | No. of Fruits |
|---|---|---|---|---|---|
| | | 15th | 30th | 45th | |
| Normal soil | 5th day | 9.3 | 16 | 23.5 | 11 |
| Soil + Trial 1 compost | 4th day | 10.1 | 14.5 | 25.4 | 13 |
| Soil + Trial 2 compost | 3rd day | 13 | 17.7 | 28.3 | 17 |

Regarding the plant development and yield study, the second experiment had a higher yield, followed by the second and first trials. This might be attributed to the varying NPK values associated with each experiment. Consequently, it may be used for agricultural purposes and marketed as organic fertilizer, leading to financial gain. This method is productive in diminishing the volume of any object by decreasing its height. The inference that can be derived from this is that this treatment modality is efficacious, especially for managing food waste, and it is also productive in generating monetary value from refuse. Each test can be widely applied, especially the second trial, which effectively combined food, vegetable, and tea waste with cow dung, chicken manure, and sawdust. These experimental combos can be utilized in residential units, hotel backyards, and other comparable environments.

## 4. CONCLUSION

The experiments demonstrated the efficiency of different composting trials in managing food waste and producing organic fertilizer. Critical factors like pH, moisture content, and organic matter were analyzed to assess the composting process. Initially, both trials exhibited acidic and alkaline pH levels, but by the end, both reached near-neutral values (6.87 for Trial 1 and 6.59 for Trial 2), indicating compost maturation. Moisture content in both trials decreased to optimal levels (37.99% for Trial 1 and 30.45% for Trial 2), ensuring proper texture and ease of application.

The organic matter content also significantly decreased, from 78.82% to 35.59% in Trial 1 and from 65.33% to 45.2% in Trial 2, highlighting the effective microbial decomposition of waste. Plant growth experiments revealed that the compost from Trial 2 resulted in higher yields due to its superior NPK values. Overall, both trials produced compost that could be used for agricultural purposes, with Trial 2 showing slightly better results regarding nutrient content and plant growth performance.

## Implications and Application

The findings suggest that both composting trials are effective waste management strategies that can transform organic waste into valuable fertilizer. Specifically, the combination of food waste with animal manure and sawdust for Trial 2 proved to be very efficient for plant growth and soil improvement. This composting process reduces the volume of waste and generates economic value by producing organic fertilizers suitable for residential, commercial, and agricultural use. Moreover, this approach could be widely adopted in hotel backyards, residential units, and small-scale farms. The ability to turn waste into an organic, nutrient-rich fertilizer provides an environmentally sustainable solution to food waste management while offering financial gains through the sale of compost.

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## CONFLICT OF INTEREST

The authors declared no conflict of interest in this manuscript regarding publication.



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