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(RESEARCH ARTICLE)

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Proximate and mineral composition of *Sargassum spp* from Badagry coast, Lagos state

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Abstract

Sargassum spp., a brown seaweed, is utilized as food in many parts of the world due to its nutritional and mineral composition. This study investigated the proximate and mineral composition of *Sargassum spp*. collected from Suntan Beach, Badagry, Lagos State, Nigeria. The samples were dried, ground, and sieved, then analyzed for proximate composition using standard methods and for mineral composition using an atomic absorption spectrophotometer (AAS). Results revealed that the seaweed contained 69.9% carbohydrate, 8.08% protein, 6.79% lipid, 3.60% moisture, and 6.47% ash. Mineral analysis indicated high concentrations of sodium (228.38 ppm) and magnesium (115.02 ppm), moderate calcium (96.40 ± 0.511 ppm), and low levels of iron (14.5 ± 0.577 ppm) and zinc (5.13 ± 0.326 ppm). Compared to *Sargassum spp*. from other regions, significant variations were observed in nutritional and mineral composition, likely due to environmental and geographical differences. These results highlight the nutritional potential of *Sargassum spp*. from Badagry as a valuable resource for food and health applications. Additionally, the study underscores its potential for environmental sustainability, given its ability to contribute to the blue economy. Further research is recommended to explore its bioactive compounds and to assess its potential for industrial and pharmaceutical applications.

Keywords: Proximate; Mineral composition; *Sargassum spp*

1. Introduction

Seaweeds are a diverse group of marine macroalgae that have garnered a lot of attention due to their ecological, nutritional, and economic significance. Marine ecosystems depend on them [Sobuj et al. [1]; Xu et al. [2]]. In addition to providing sustainable biomass for biofuels and global food security, seaweeds support a variety of industries, such as agriculture, cosmetics, and pharmaceuticals [Sudhakar et al. [3]; Hefft & Adetunji [4]]. They are rich in essential nutrients such as proteins, vitamins, minerals, and bioactive compounds with anti-inflammatory, anti-microbial, and antioxidant properties. Peñalver et al. [5]. Because of its high mineral content and potential applications in bioremediation, nutraceuticals, and functional foods, the brown seaweed genus *Sargassum spp.* is particularly noteworthy. Chopin & Tacon [6]. Despite their importance on a global scale, little is known about the nutritional profiles of seaweeds in many coastal areas, such as the Badagry coast of Nigeria. This highlights the need for localized research to fully realize the potential of seaweeds and encourage sustainable use.

The proximate composition of seaweeds encompasses the study of their primary nutritional components, including moisture, protein, lipids, ash, fiber, and carbohydrates. This analysis is crucial to determine the nutritional value and potential applications of seaweeds in the food and non-food industries. Seaweed-based products' shelf life and preservation methods are influenced by their moisture content, while proteins enable them to serve as a source of

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essential amino acids. Premarathna et al. [7]. Because they contain polyunsaturated fatty acids, which are beneficial to human health, lipids are significant even though they are usually present in trace amounts. Campos et al. [8]. According to Mengisteab et al. [9], the amount of ash indicates the mineral composition and supplies vitamins, minerals, and potassium that are vital for human nutrition. Seaweed's ability to support digestive health is improved by dietary fiber, and its main energy source is carbohydrates D'Armas et al. [10]. The nutritional potential of seaweed is emphasized by proximate analysis, which also emphasizes their significance for food security as nutrient-dense, sustainable food sources. Additionally, their industrial uses include components for cosmetics and bioplastics as well as bioactive compounds for therapeutic purposes. Premarathna et al. [7]; Mengisteab et al. [9].

Minerals are essential for both human and animal nutrition because they support a number of physiological functions, including cellular signaling, enzymatic activity, and bone formation Carter et al. [11]. Significant concentrations of calcium, potassium, magnesium, sodium, and phosphorus are among the essential minerals found in seaweeds, which are natural stores of these elements. Aknaf et al. [12]; Premarathna et al. [7]. Seaweeds' mineral makeup improves their biotechnological and pharmacological uses in addition to supporting dietary supplementation. For example, because of their bioavailability and suitability for human health, their rich mineral profile has been used to create therapeutic agents and functional foods. Lomartire & Gonçalves [13]; Pradhan et al. [14]. Furthermore, the incorporation of seaweeds into pharmaceutical formulations highlights their potential to take the place of synthetic compounds, providing sustainable alternatives for drug development. Nabti [15]. Seaweeds are therefore essential resources for both nutritional and industrial advancements due to their mineral richness.

Seaweeds are generally divided into three main phyla based on the differences in their pigmentation: Rhodophyta (red seaweeds), which have the pigments of phycoerythrin and phycocyanin; Phaeophyta (brown seaweeds), which have the pigments of fucoxanthin and chlorophyll a and c; and Chlorophyta (green seaweeds), which have the pigments of chlorophyll a and b along with various distinctive xanthophylls. O'Sullivan et al. [16]. Sargassum belongs to the Phylum Ochrophyta, class Phaeophyceae and constitutes a distinct taxonomic group due to their morphological, anatomical and physiological complexities. It is the most diverse genus of marine macrophytes in tropical waters. Xie et al. [17]. Sargassum is a genus of brown algae in the order Fucales, comprising approximately 1500 species worldwide. Addico & deGraft-Johnson [18]. These species play significant ecological and economic roles in tropical and temperate marine environments Yap-Dejeto et al. [19]. These macroalgae serve as essential primary producers, supporting a range of marine communities by providing various marine organisms food, oxygen, and habitat. Siuda et al. [20]. Sargassum is a valuable resource in the industrial sector because of its sulfated polysaccharides, which have bioactive qualities such as anticoagulant, antibacterial, and antioxidant effects. As a result, it may be used as an ingredient in vitamins, cosmetics, and medications. Sanjeewa et al. [21]. Recent research also emphasizes its potential to promote the circular economy through its use in bioremediation, sustainable biofuel production, and agricultural applications Orozco-González et al. [22]; Saldarriaga-Hernandez et al. [23].

The biodiversity of seaweeds in Nigerian waters, especially along the coast of Lagos State, is still largely unexplored despite its ecological and commercial importance. The distribution of *Sargassum spp.*, a genus of brown algae, is especially significant because they bloom occasionally and are affected by nutrient inflow from the Guinea Current. Solarin et al. [24]. *Sargassum spp.* commonly settle on beaches along the Lagos coast, posing environmental and financial problems like disrupting fishing and raising cleanup expenses. At the same time, the genus has enormous potential for environmental, aquaculture, and biotechnology applications. Kadiene et al. [25]; Stiger-Pouvreau et al. [26]. Studying Sargassum in Nigeria is crucial for developing strategies to mitigate its adverse effects while harnessing its benefits to support sustainable development and the blue economy.

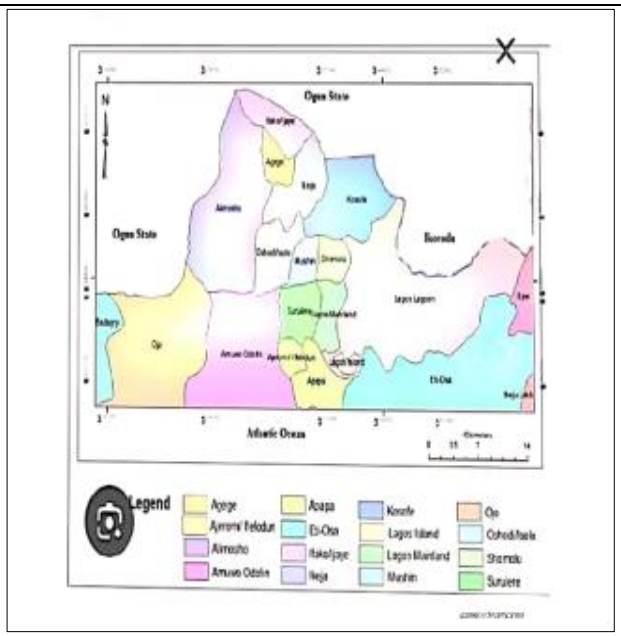
Despite the increasing global interest in the utilization of *Sargassum spp.* for its ecological and economic benefits, limited data exists on the proximate and mineral composition of these seaweeds from Nigeria's coastline, particularly from Badagry. This knowledge gap hinders the full exploration of *Sargassum spp.* as a sustainable resource in addressing food security, health, and environmental challenges. Sargassum species are rich in nutrients, which makes them potentially useful in a variety of fields. These include as a biofortified food supplement, a source of bioactive compounds for pharmaceutical applications, and a sustainable alternative to synthetic fertilizers. The current study aims to analyze the proximate and mineral composition of *Sargassum spp.* from the Badagry coastline, highlighting its utility as a sustainable resource for food, health, and environmental applications. This research will provide baseline data essential for promoting the sustainable harvesting and utilization of *Sargassum spp.* in Nigeria, thereby supporting national and global efforts in achieving sustainability goals.

2. Materials and Methods

2.1. Description of study area

The study was conducted at Badagry Coast, located in Lagos State, Nigeria, along the southwestern coastline of the country. Badagry is a coastal town known for its historical significance and rich marine biodiversity. The area is characterized by its tropical climate, with a mix of saltwater and brackish environments that support a variety of marine life, including seaweeds like *Sargassum spp.* The coastline is influenced by the Atlantic Ocean, with various human activities, including fishing and tourism, playing significant roles in the local economy. The region's coastal ecosystem provides an ideal setting for studying the proximate and mineral composition of marine organisms.

* SAMPLE SITE



LOCAL GOVERNMENT

Figure 1 Localization of sampling sites on Suntan Beach Badagry Lagos State

2.2. Material

- **Reagents-** Hydrochloric acid, Anthrone reagent, Glucose, Methanol, Chloroform, Sulphuric acid, Sodium hydroxide, Concentrated H2SO4, Boric acid, Methyl red, Nitric acid, Perchloric acid.

- **Equipments -** Centrifuge (Techmel and Techmel USA, Model:412B), Ultraturrax mixer (T 25 digital ULTRA-TURRAX, IKA, 120V), Oven (DHG-9101.ISA), Desiccators (Stainless Steel), Water bath (Thermo Precision 2864), Blender (Flourish® electric blender (Model: BL-Y445), Atomic absorption spectrometer (Model XplorrAA).

2.3. The Sample

Sagassum spp. was obtained from Suntan beach, Badagry, Lagos State.

2.4. Methods

2.4.1. Preparation of the Sample

The collected seaweeds were washed in tap water and in distilled water and dried at room temperature. The sample was ground using a blender and was sieved, then it was kept in an air tight container.

2.5. Proximate Analysis of the Sample

2.5.1. Moisture content

The method described by Abu-Tarboush et al. [27] was adopted. The method is based upon the removal of water from the sample and its measurement by loss of weight. 3A clean crucible was weighed and dried in the oven (W1); 1.0 g of each of the samples was weighed into the crucible (W2) and was dried at 105°C, for twenty-four hours. The crucible was then transferred from the oven to desiccator, cool and reweighed (W3). The % moisture content was calculated from: % Moisture content =100- (w3-w1/w2-w1 x100)

2.6. Determination of total Carbohydrate

Total carbohydrate estimation was determined by Phenol-sulphuric acid method Hoboken et al. [28]. A 200 mg portion of sample was added to 5 ml of 2.5 N HCl and the sample was hydrolyzed by keeping in boiling water bath for 3 h. The solution was neutralized by adding solid Na2CO3 until effervescence ceases. The volume was then made to 50 ml and centrifuged at 8000 rpm for 10 min. The supernatant was collected and about 0.5 ml of it was aliquoted in a test tube. The sample was made to 1 ml with distilled water and 1 ml of phenol solution was added to the sample along with 5 ml of 96% sulphuric acid. The solution was mixed well and placed in water bath for 20 min at 25^{o} C. The absorbance was measured at 490nm using UV-Visible spectrophotometer.

2.7. Determination of crude fibre

The method described by AOAC Sales and Hayes [29] was used. A 1.0 g portion of finely ground sample was weighed out into a round bottom flask, 100ml of 1.25% Sulphuric acid solution was added and the mixture boiled under a reflux for 30 min. The hot solution was quickly filtered under suction. The insoluble matter was washed several times with hot water until it was acid free. It was quantitatively transferred into the flask and 100 ml of hot 1.25% sodium hydroxide (NaOH) solution was added and the mixture boiled again under reflux for 30 min and quickly filtered under suction. The soluble residue was washed with boiling water until it was base free. It was dried to constant weight in the oven at 105°C, cooled in a desiccator and weighed (C1).The weighed sample (C1) was incinerated in a muffle furnace at 300oC for about 30 minutes, cooled in the desiccators and reweighed (C2).

The loss in weight of sample on incineration = C1 – C2. x 100

Weight of original sample

% Crude fibre = C1 - C2

2.7.1. Total ash content

The AOAC Sales and Hayes [29] 1996) method was used. The porcelain crucible was dried in an oven at 100°C for 10 min, cooled in a desiccator and weighed (W1). Two grams of the sample was placed into the previously weighed porcelain crucible and reweighed (w2) and then placed in the furnace for four hours at 600°C to ensure proper ashing. The crucible containing the ash was removed cooled in the desiccator and weighed (w3).

The % ash content was calculated as:

$$\% \text{ ash content} = \frac{w2 - w1}{w3 - w1} \times 100$$

2.8. Crude Protein Determination

The micro kjeldahl method described by Kamishikiryo-Yamashita et al. [30] was used. Two grams of each of the samples was mixed with 10ml of concentrated H2SO4 in a heating tube. One tablet of selenium catalyst was added to the tube and mixture heated inside a fume cupboard. The digest was transferred into distilled water. Ten millimeter portion of the digest mixed with equal volume of 45% NaOH solution and poured into a kjeldahl distillation apparatus. The mixture was distilled and the distillate collected into 4% boric acid solution containing 3 drops of methyl red indicator. A total of 50ml distillate was collected and titrated as well. The sample was duplicated and the average value taken. The Nitrogen content was calculated and multiplied with 6.25 to obtain the crude protein content.

2.8.1. This is given as percentage

- Nitrogen= (100 x N x 14 x VF) T100 x Va

Where

- N= Normality of the titrate (0.1N)
- VF= Total volume of the digest= 100ml
- T= Titre Value
- Va= Aliquot Volume distilled

2.9. Determination of Lipid

A 5-10 g dry sample was weighed in a pre-weighed 100 mL- conical flask, 20 mL methanol (MeOH) and 10 mL chloroform (CHCl3) was added and homogenize for 2 min with an UltraTurrax mixer. 10mL $CHCl_3$ was added the second time. The mixture was shaken vigorously for 1 min. 18mL of distilled water was added (including the water already in the sample) and the mixture was vortex again for 1 min. The mixture was centrifuged at 20°C for 10 min at 450nm, the lower layer was transferred to a pear-shaped flask with a Pasteur pipette. The second extraction was done with 20 mL 10% (v/v) MeOH in CHCl3 by vortexing for 2 min. After centrifugation, the lower CHCl3 phase was added to the first extract, the sample was evaporated to dryness (e.g. with a rotavapor), the residue was further dried at 104°C for 1h. The extracted weight and calculate the lipid content was record.

2.10. Determination of Mineral Elements

One gram of the samples was weighed into the digestion flask of 250 ml capacity a 25 ml of Nitric acid, perchloric and sulphuricacid was added to each sample. The flask was fixed to a clamp and kept overnight. When the initial reaction subsided, the temperature of the micro digestion bench was increased slowly from 180°C to 200°C. The digestion was continued at that temperature until no visible particles observe, the temperature was raised up to 240°C and the digestion acid was evaporated until dense white fume formed within the digestion flask. After the digestion was completed, the content of the flask was filtered and the digested material was kept in a dust proof glass chamber. The samples were digested with the disappearance of brown fumes, diluted to 100ml for ASS Analysis using suitable hallow cathode lamp.

2.11. Statistical analysis

All the analyses were performed in triplicates and the results were statistically analyzed and Expressed as mean (n=3) ± standard error of mean (SEM).

3. Results

3.1. Proximate Analysis

Table 1 Proximate composition of *Sargassum spp*

Proximate composition	Percentage (%)
Carbohydrate	69.96 ± 0.141
Protein	8.08 ± 0.208
Crude fat	6.79 ± 0.207
Moisture	3.60 ± 0.042
Ash	6.47 ± 0.023
Crude fibre	5.50 ±0.014

The proximate composition of *Sargassum spp.* reveals its nutritional potential, with carbohydrates constituting the highest proportion at 69.96 ± 0.141%, indicating its suitability as an energy source. The protein content, 8.08 ± 0.208%, is moderate, suggesting its potential as a supplementary protein source. The crude fat content of 6.79 ± 0.207% highlights its lipid contribution, which could be useful in energy and metabolic processes. The moisture content, 3.60 ± 0.042%, is relatively low, enhancing its shelf life and storage stability. The ash content, 6.47 ± 0.023%, reflects its mineral richness, while the crude fiber content of 5.50 ± 0.014% supports its potential in promoting digestive health. These findings underscore the nutritional value of *Sargassum spp.* and its potential applications in food and industrial uses.

Table 2 Mineral composition of *Sargassum spp.*

Mineral	**ppm**
Fe	14.15 ±0.577
Na	228.38 ±1.608
Mg	115.02 ±0.548
Ca	96.40 ±0.511
Zn	5.13 ± 0.326

The result was expressed in mean ± standard error

The mineral composition of *Sargassum spp.* indicates a diverse array of essential nutrients, with sodium (Na) being the most abundant at 228.38 ± 1.608 ppm, highlighting its potential as a natural source of electrolytes. Magnesium (Mg), at 115.02 ± 0.548 ppm, and calcium (Ca), at 96.40 ± 0.511 ppm, underscore its importance in bone health and metabolic functions. The iron (Fe) content of 14.15 ± 0.577 ppm suggests its potential role in addressing iron deficiency and promoting oxygen transport in the body. Zinc (Zn), present at 5.13 ± 0.326 ppm, further adds to its nutritional value due to its significance in immune function and enzymatic activities. These results emphasize the potential of *Sargassum spp.* as a valuable source of minerals for nutritional and therapeutic applications.

4. Discussion

The proximate composition of *Sargassum spp.* analyzed in this study reveals that the macroalgae is predominantly composed of carbohydrates (69.96 ± 0.141%), followed by protein (8.08 ± 0.208%), crude fat (6.79 ± 0.207%), ash (6.47 ± 0.023%), crude fiber (5.50 ± 0.014%), and moisture (3.60 ± 0.042%). The high carbohydrate content aligns with findings from Indriyawati et al. [27], who reported carbohydrate levels of 73.5% in *Sargassum* sp. This dominance of carbohydrates underscores the potential of *Sargassum* as an energy source and its application as a functional food ingredient. Similarly, Paul et al. [28] observed carbohydrate contents between 65.1–67.9% in *Sargassum wightii* and *Sargassum thunbergii*.

The protein content (8.08 ± 0.208%) observed is comparable to the values reported by Dewinta et al. [29] for *Sargassum cristaefolium* (8.54%) and slightly higher than the 4.3% reported by Indriyawati et al. [27]. This variation could be attributed to species differences, collection sites, and environmental factors. The fat content in this study (6.79 ± 0.207%) is significantly higher than the <1% observed in most studies, such as Winarni et al. [30] and Yucetepe et al. [31], suggesting that *Sargassum spp.* from this region may possess unique lipid profiles influenced by habitat. The ash content (6.47 ± 0.023%) is lower than the 12.5–16.3% reported by Paul et al. [28] and 27.09% by Arguelles et al. [32], reflecting possible variations in mineral composition. However, it highlights the potential of *Sargassum spp.* as a source of essential minerals. Crude fiber content (5.50 ± 0.014%) is consistent with reports from Dewinta et al. [29] and Arguelles et. al. [32], suggesting its utility as a dietary fiber source.

The findings underscore the nutritional versatility of *Sargassum spp.* The high carbohydrate content enhances its application in food and pharmaceutical industries as a functional food component, while its protein and crude fiber content offer dietary benefits. The observed discrepancies in fat and ash content compared to other studies indicate the influence of environmental factors and suggest the potential for further exploration of *Sargassum spp.* from different regions. *Sargassum spp.* demonstrates great potential for nutritional and industrial applications.

Furthermore, the mineral composition of *Sargassum spp.* in this study, presented in Table 2, reveals high levels of sodium (Na, 228.38 ppm), magnesium (Mg, 115.02 ppm), and calcium (Ca, 96.40 ppm), with moderate iron (Fe, 14.15 ppm) and zinc (Zn, 5.13 ppm) content. These findings underscore the potential of *Sargassum spp.* as a rich source of essential minerals, which are vital for numerous physiological and metabolic functions in humans and animals. The results align with previous reports that highlight the mineral richness of *Sargassum spp.* For example, Yucetepe et al. [31] reported that brown macroalgae, including *Sargassum spp.*, are rich in Mg, Ca, and Fe, with significant levels of Na. Similarly, Paul et al. [28] found that Sargassum wightii and Sargassum thunbergii from Tamil Nadu displayed elevated Ca (14,805–16,235 ppm) and Zn (3.95–4.86 ppm) levels, supporting the present study's observation of calcium's prominence. Although the specific values differ due to regional, environmental, and species-specific variations, the consistent presence of these minerals highlights their biological importance and wide-ranging applications. The Fe

content in this study (14.15 ppm) surpasses the levels reported by Yucetepe et al. [31] (6.97–18.78 mg/kg) and Paul et al. [28] (8.14–12.41 ppm), suggesting that local environmental factors or growth conditions may have influenced mineral uptake. However, the Zn content in this study (5.13 ppm) is comparable to the values reported by Paul et al., further validating the consistency of Zn in *Sargassum spp.* worldwide.

The findings reiterate the nutritional potential of *Sargassum spp.*, particularly in addressing mineral deficiencies in human diets. High Na and Mg levels suggest its applicability in the formulation of mineral supplements, while the significant Ca content highlights its potential use in bone health products. The Fe content further enhances its appeal for addressing anemia-related challenges, especially in regions where iron deficiency is prevalent. However, the high Na content may limit its direct consumption for individuals with sodium-restricted diets. This concern can be mitigated through processing techniques such as rinsing or extraction, as recommended by Silva et al. [33]. Overall, the mineral profile of *Sargassum spp.* positions it as a valuable resource for functional foods, pharmaceuticals, and nutraceuticals.

5. Conclusion

The proximate and mineral composition analysis of *Sargassum spp.* from the Badagry Coast, Lagos State, revealed its potential as a valuable nutritional resource. The proximate analysis highlighted that *Sargassum spp.* is predominantly composed of carbohydrates, making it a significant source of energy. Moreover, it contains moderate levels of protein and crude fat, along with appreciable amounts of ash and crude fiber, which suggest potential benefits for dietary and industrial applications. The mineral composition analysis revealed high levels of sodium and magnesium, with calcium and iron contributing to its nutritional value. Zinc, though present at a lower concentration, adds to its micronutrient profile. These findings emphasize *Sargassum spp.* as a rich source of essential nutrients that could be explored for applications in food fortification, health supplementation, and other industries. This study underscores the importance of *Sargassum spp.* as a sustainable resource, with its nutrient-dense profile offering opportunities for its incorporation into various value-added products. Future research should focus on the bioavailability of these nutrients and explore the potential environmental and seasonal factors influencing its composition for optimized utilization.

Recommendation

Based on the findings of this study, the following recommendations are proposed:

- Efforts should be made to explore the integration of *Sargassum spp.* into food products, particularly as a supplement in diets lacking essential minerals such as calcium, magnesium, and iron. Its high carbohydrate and protein content also make it suitable for energy-dense and protein-rich formulations.
- The fiber and ash content of *Sargassum spp.* suggest potential applications in the production of biofertilizers, animal feed, and other agro-industrial products. Further studies should optimize these uses to enhance its economic value.
- Research should be encouraged to extract and refine specific bioactive compounds from *Sargassum spp.*, such as alginates and antioxidants, for applications in pharmaceuticals, nutraceuticals, and cosmetics.
- To prevent overexploitation and ensure environmental sustainability, efforts should be directed toward cultivating *Sargassum spp.* under controlled conditions. Policies should also regulate its harvesting from natural habitats along the Badagry Coast.
- Awareness campaigns should be launched to educate local communities and stakeholders about the nutritional and economic potential of *Sargassum spp.* This would encourage its adoption as a valuable resource.

Future studies should evaluate the seasonal variations, environmental impacts, and bioavailability of nutrients in *Sargassum spp.*. Additionally, exploring its safety for human consumption, including potential allergenic or toxic effects, is essential for broader applications.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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