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Full Length Research Article

PHYSICO-CHEMICAL CHARACTERIZATION OF TAMARIND SEED (*TAMARINDUS INDICA*) POWDER AS A NATURAL COAGULANT FOR WATER PURIFICATION

*[1]M.S. Ayuba, [1]A.M. Alaba, [2]B.S. Peter, [3]C.A. Kendeson

[1]Department of Science Laboratory Technology, University of Jos, Plateau State, Nigeria
[2]Department of Technical Education, Federal College of Education, Jama'are, Bauchi State, Nigeria
[3]Department of Chemical Sciences, Federal University of Kashere, Gombe State, Nigeria

*Corresponding Author Email Address: magdalenea@unijos.edu.ng

ABSTRACT
This study evaluates tamarind (*Tamarindus indica*) seed powder as an affordable and eco-friendly natural coagulant for improving drinking water quality. Physico-chemical parameters—including moisture, ash content, pH, colour, conductivity, and bulk density—were analysed using standard methods. Elemental composition was determined using X-ray fluorescence (XRF). Coagulation efficiency was assessed through jar tests on raw well water samples. Tamarind seed powder exhibited low moisture (9.29%) and ash (4.46%) contents, a slightly acidic pH (5.35), and a mineral profile dominated by potassium, calcium, sulphur, and iron. Turbidity removal increased with coagulant dosage, reducing turbidity to below 5 NTU, meeting WHO recommendations for potable water. These findings demonstrate the potential of tamarind seed powder as an effective natural coagulant suitable for decentralized water purification in low-income communities.

Keywords: *Tamarindus indica*, natural coagulant, turbidity reduction, water treatment, XRF

INTRODUCTION
Access to microbiologically safe drinking water remains a persistent challenge in many developing regions, particularly rural communities that rely on untreated surface and groundwater for domestic use. These water sources commonly contain suspended solids, dissolved organic matter, and pathogenic microorganisms responsible for diseases such as typhoid fever, cholera, and dysentery (WHO, 2022). Although groundwater is often considered safer, contamination arising from poor sanitation, agricultural runoff, and industrial discharges has become increasingly widespread (Akan, Abdulraheem & Sallau, 2016).
Chemical coagulants such as aluminium sulphate and ferric chloride are widely used in water treatment due to their efficiency in destabilizing colloidal particles. However, concerns about cost, sludge generation, and potential health implications associated with residual metals have encouraged the search for safer, low-cost alternatives (Ndabigengesere & Narasiah, 1998; Yin, 2010).
Natural coagulants derived from plants offer advantages including biodegradability, low toxicity, and local availability, making them particularly attractive for decentralized or rural water treatment systems (Amagloh & Benang, 2009; Asadullah et al., 2018).
Tamarindus indica is a tropical species whose seeds contain polysaccharides and proteins with functional groups capable of promoting coagulation through mechanisms such as charge neutralization and particle bridging (Jayaram, Gideon & Rao, 2018; Kumar & Susheela, 2019). Although previous studies have explored the coagulating potential of tamarind seed extracts and powders, information regarding the specific physicochemical and mineral characteristics that influence performance remains limited, particularly in rural water sources with varied quality (Fatombi et al., 2014; Dovi, Abdullahi, & Musa, 2020). This study, therefore, examines the physicochemical and elemental properties of tamarind seed powder and assesses its coagulation efficiency in treating raw well water from Kaben Furaka village, Jos North, Plateau State, Nigeria. The findings aim to contribute to the development of sustainable, community-level alternatives to conventional chemical water treatment systems.

MATERIALS AND METHODS
Collection and Preparation of Tamarind Seeds
Tamarind seeds were purchased from Farin-Gada Market, Jos, Plateau State, Nigeria, located at approximately latitude 9◦ 56´ N and longitude 8◦ 54´ E. Seeds were cleaned, soaked for 12 hours, dehulled, washed, oven-dried at 105 °C for 24 hours, milled, and sieved through a 250 µm mesh. Powder was stored in airtight containers.

Figure 1 — Tamarind seed and powder

Collection of Water Samples
Raw well water samples were collected from three wells in Kaben Furaka village located at approximately latitude 9◦ 85´ N and longitude 8◦ 97´ E. Samples (X, Y, Z) were collected into clean polyethylene bottles and transported to the laboratory within 2 hours.

Physico-Chemical Analysis
Moisture and ash contents were determined using AOAC (2016) methods. pH, colour, conductivity, and bulk density were analysed with standard laboratory procedures. Briefly, the processes are described as:

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Determination of moisture content: A 5g sample of the ground plant samples was measured in triplicate into pre-weighed Petri-plates. The samples were oven-dried at 105 °C for 24 hours; this was done in triplicate. The loss in weight after drying was expressed as % moisture according to the formula given in the equation below:

$$[(W_2 - W_3) \div (W_2 - W_1)] \times 100$$

Where: W_1 = weight of petri dish alone; W_2 = weight of petri dish + sample before drying; W_3 = weight of petri dish + sample after drying.

Determination of ash content: The sample (2 g) was placed in pre-weighed porcelain crucibles and then placed in a muffle furnace maintained at 600 °C for 8 hours, after ashing it was then allowed to cool in a desiccator. The cooled crucible containing the ashed sample was weighed, and the ash content was calculated using equation [2]; this was done in triplicate.

$$\% \text{ Ash content} = [(W_3 - W_1) \div (W_2 - W_1)] \times 100$$

Where: W_1 = weight of empty crucible; W_2 = weight of crucible + weight of sample before ashing; W_3 = weight of crucible + weight of sample after ashing.

The physical properties of tamarind seed powder were determined pH test: about 2 g of the sample (tamarind seed powder) was weighed and transferred to a clean beaker, and 60 mL of distilled water was added and shaken properly. The pH was determined using an electronic pH device, and the reading was taken.

Bulk density: Empty measuring cylinder was weighed on a digital weighing balance. About 1 g of the sample (tamarind seed powder) was transferred into the measuring cylinder and weighed. It was removed and compressed again to be compacted and re-weighed for the second time to get the actual reading. Thus the formula: $BD = [(W - A) \div (B - A)]$

Where: A = weight of empty measuring cylinder; W = weight of measuring cylinder + sample; B = weight of compacted sample + measuring cylinder

Color: About 2 g of the sample (tamarind seed powder) was weighed and transferred to a clean 150 mL beaker, and 60 mL of distilled water was added, shaken properly, and allowed to stand. It was then placed in a Lovibond comparator machine, and the reading was observed properly.

Conductivity: About 2 g of the sample (tamarind seed powder) was weighed and transferred to a clean beaker, and 60 mL of distilled water was added and shaken properly. The conductivity was determined using a conductivity meter, and the reading was observed properly.

Elemental Analysis

Elemental composition was determined using XRF- X-Ray Fluorescence (Model: Thermo Scientific Niton XL3t). The sample (Tamarind seed powder) was ground into a fine powder (<75µm) to ensure homogeneity. About 1g of the powdered sample is fused into the glass bead for analysis. Concentrations of major and trace elements were recorded in ppm and percentage composition.

Jar Test Procedure

Jar tests were performed using 500 mL of water with coagulant dosages of 100–350 mg/L. Rapid mixing (200 rpm, 2 min) was followed by slow mixing (40 rpm, 20 min) and a 30 min settling period. Supernatant was analysed for turbidity, pH, alkalinity, and hardness.

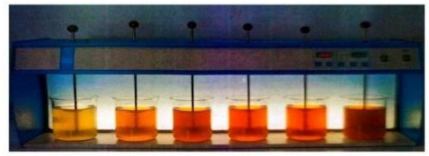

Figure 2— Jar test experimental setup

RESULTS

Physico-Chemical Properties of Tamarind Seed Powder

The proximate composition of tamarind seed powder is presented in Table I. The powder exhibited a moisture content of 9.29 ± 0.23% and an ash content of 4.46 ± 0.54%. These values indicate good storage stability and the presence of inorganic constituents that may support coagulation performance.

TABLE I — Proximate Composition of Tamarind Seed Powder

Parameter	Value (%)
Moisture	9.29 ± 0.23
Ash	4.46 ± 0.54

XRF analysis revealed that potassium, calcium, sulphur, and iron were the most abundant elements, with potassium occurring at 14,981.41 ± 2356.79 ppm. Table II provided the elemental concentration results. Trace metals such as zinc, copper, and lead occurred at low levels.

TABLE II — Elemental Composition of Tamarind Seed Powder (XRF Analysis). Copper and lead were present in low concentrations.

Element	Concentration (ppm)	Percent (%)
Mo	9.49 ± 1.41	0.00095
Zr	6.96 ± 1.38	0.00070
Sr	14.14 ± 1.17	0.00141
Rb	44.55 ± 2.00	0.00445
Pb	16.46 ± 2.92	0.00165

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Element	Concentration (ppm)	Percent (%)
Zn	52.85 ± 5.54	0.00529
Cu	15.92 ± 7.72	0.00159
Fe	1160.27 ± 38.58	0.11603
Ca	3382.02 ± 77.09	0.33820
K	14981.41 ± 2356.79	1.49814
S	2200.67 ± 228.86	0.22007
Nb	9.84 ± 1.57	0.00098

TABLE III — Physical Properties of Tamarind Seed Powder

Parameter	Value
Bulk density	1.11 g/cm³
pH	5.35
Conductivity	0.51 mS/cm
Colour	6.5 (Milky yellow)

The raw well water samples exhibited high turbidity, moderately acidic pH, and varied alkalinity and hardness values (Table IV). These characteristics indicate the need for coagulation treatment

TABLE IV — Raw Water Quality

Sample	pH	Alkalinity (mg/L)	Hardness (mg/L)	Turbidity (NTU)
X	6.42	130	18	106.80
Y	6.36	96	36	90.30
Z	6.47	118	22	83.60

Coagulation Performance of Tamarind Seed Powder

Tamarind seed powder demonstrated significant improvement in water quality across all three water samples. Increasing coagulant dosage resulted in progressive reductions in turbidity and alkalinity, while pH and hardness values remained within acceptable limits.

Turbidity was most effectively reduced at dosages between 250–350 mg/L, bringing treated water within the WHO recommended range (< 5 NTU). Table V shows the treatment performance across all dosages

TABLE V — Treated Water at Different Coagulant Dosages

Sample	Dosage (mg/L)	pH	Alkalinity (mg/L)	Hardness (mg/L)	Turbidity (NTU)
X	100	6.47	112	18	18.50
	150	6.52	102	17	12.60
	200	6.63	93	17	8.30
	250	6.68	63	15	5.10
	300	6.72	40	18	3.30
	350	6.90	37	22	3.10
Y	100	6.43	80	35	15.30
	150	6.43	71	34	11.40
	200	6.62	50	32	7.10
	250	6.65	43	31	4.50
	300	6.71	32	33	3.00
	350	6.87	26	35	2.40
Z	100	6.51	108	22	11.10
	150	6.58	96	21	8.30
	200	6.68	83	21	6.70
	250	6.76	56	19	3.70
	300	6.83	35	20	2.90
	350	7.10	32	21	2.20

DISCUSSION

The findings of this study indicate that tamarind seed powder possesses favourable properties for use as a natural coagulant in water purification. The proximate analysis revealed low moisture and ash contents, consistent with previous studies, suggesting good storage stability and the presence of mineral constituents that support coagulation (Ahmed & Daffalla, 2019). The slightly acidic pH aligns with earlier reports and suggests that the coagulant is unlikely to have adverse effects on treated water acidity (Fatombi et al., 2014).

Mineral analysis confirmed high levels of potassium, calcium, sulphur, and iron, which may contribute to coagulation through charge neutralization and floc formation. Multivalent ions such as calcium and iron have been shown to enhance particle aggregation in plant-based coagulants (Okuda et al., 2001; Nkurunziza et al., 2009; Ndabigengesere & Narasiah, 1998).

The raw well water exhibited high turbidity levels, underscoring the need for effective clarification. Significant turbidity reduction was achieved across all samples, with optimal removal occurring at 250–350 mg/L. These values are comparable to the performance of other natural coagulants such as *Moringa oleifera* seed extract and tamarind kernel powder reported in the literature (Giwa, Ogunbiyi & Olawale, 2017; Dovi, Abdullahi & Musa, 2020).

Minimal shifts in pH suggest that the tamarind seed powder interacts only mildly with the water's buffering system, maintaining treated water within acceptable limits (Akan, Abdulraheem & Sallau, 2016). Alkalinity reductions followed expected patterns associated with coagulation processes, and hardness levels remained relatively stable.

Overall, the results demonstrate that tamarind seed powder is an efficient, affordable, and environmentally friendly coagulant suitable for improving drinking water quality in resource-limited settings (Yin, 2010; Asadullah et al., 2018). Further investigation into extraction optimization and large-scale application is recommended.

Conclusion

This study demonstrates that tamarind seed (*Tamarindus indica*) powder possesses favourable physico-chemical and mineral characteristics that support its use as an effective natural coagulant for water purification. The powder exhibited low moisture and ash contents, slightly acidic pH, and appreciable levels of potassium, calcium, sulphur, and iron, which likely contribute to its coagulation potential. Jar test experiments showed substantial turbidity reduction across all water samples, with treated water meeting WHO recommendations at dosages of 250–350 mg/L. Minimal changes were observed in pH, alkalinity, and hardness, indicating that the coagulant does not significantly disrupt water chemistry.

Given its affordability, local availability, and environmentally friendly nature, tamarind seed powder represents a viable alternative to conventional chemical coagulants, particularly for use in rural or resource-limited communities. Further studies should investigate optimization of extraction methods, identification of active coagulating compounds, and the feasibility of large-scale application.

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