Chemical Science International Journal

19(3): 1-9, 2017; Article no.CSIJ.34041
ISSN: 2456-706X
(Past name: American Chemical Science Journal, Past ISSN: 2249-0205)

Biodisinfection and Coagulant Properties of Mixed *Garcinia kola* and *Carica papaya* Seeds Extract for Water Treatment

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Authors' contributions

This work was carried out in collaboration between all authors. Author BIU suggested the study while author JCN designed the study and performed the statistical analysis. Author OJK wrote the protocol and managed the analyses in the study. Author JCN wrote the first draft of the manuscript while author BIU managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CSJI/2017/34041
Editor(s):
(1) Mohammad Luqman, Department of Basic Science, College of Applied Sciences, A'Sharqiyah University, Oman.
Reviewers:
(1) Miraji Hossein, University of Dodoma, Tanzania.
(2) Arnaldo Sarti, Instituto de Quimica (Unesp/Araraquara-SP), Brazil.
(3) G. Revathi, Bharathiar University, Tamil Nadu, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/19509

Original Research Article

Received 10th May 2017
Accepted 29th May 2017
Published 13th June 2017

ABSTRACT

Garcinia kola (Heckel) and *Carica papaya* (Linn.) seeds from ripe fruits were investigated for their disinfection and coagulation activity in water. The phytochemical analysis indicated the presence of alkaloid, saponins, flavonoid and tannins in both seeds. Physicochemical analysis of the water samples was determined before and after treatment with seed solutions. Results showed that mixed *Garcinia kola* and *Carica papaya* extracts had no significant effect (P > .05) on temperature, pH, conductivity and chloride but significantly reduced (P = .05) TDS, BOD, nitrate, nitrite and turbidity. The coagulation and antimicrobial efficiency of mixed *Garcinia kola* Heckel and *Carica papaya* seed solution at different concentrations on turbid surface water (collected from Ogbor Hill River in Aba) were studied and compared. Microbial reduction for mixed extract of *Garcinia kola* and *Carica papaya* solution showed antimicrobial efficiency of 41.67 – 83.33% for Total coliform,

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47.85 – 60.89% for *E. coli*, 12.87-83.33% for *Fecal streptococcus*, 40.46 – 83.33% for *staphylococcus Aureus* and 50.43 – 74.36% for Total heterotrophic bacteria at different concentration. Mixed *Garcinia kola* and *Carica papaya* seed solution reduced the turbidity perfectly at the optimum doze of 3% at which 67.83% turbidity was removed by mixed solution. *Garcina kola* and *Carica papaya* seeds are non toxic and do not significantly affect the pH and conductivity of the treated water. So, as natural coagulants, both seeds may be potentially viable for treating water.

Keywords: Kola; papaya; disinfection; coagulation; water treatment.

1. INTRODUCTION

The level of purity of water consumed by humans is crucial since it has direct effect on health. Despite the technological advancement in water treatment and supply, one major challenge faced by many developing countries today is lack of clean and safe drinking water for use by their citizens. It has been observed that, 1.2 billion people do not have clean and safe drinking water globally [1]. In Nigeria for instance, some municipalities spend roughly 50% of their annual recurrent cost on water supply [2]. In most third world countries, many communities depend to an extent on surface water sources for their domestic water supply. River water drawn for consumption is of high turbidity, especially in the rainy season. Studies have shown that, one major problem with the treatment of surface water is the large seasonal variation in turbidity [3]. The consumption of highly turbid water may lead to water borne disease outbreak. Water and water related diseases such as diarrhoea, typhoid and cholera are fast becoming endemic in certain parts of Africa [1,4]. To control these diseases, water needs to be purified in order to make it safe for human consumption in accordance with WHO standards. However, for many developing countries, coagulation, flocculation and sedimentation are expensive processes of water treatment because of the high cost involved in importing chemicals with hard currency, leading to high pricing for treated water and the difficulties in accessing the chemicals [5,6]. Chemical disinfectants like chlorine are not only expensive but have some health effects and environmental problems. Its usage may result in the production of water disinfection by-products such as trihalomethane, a cancer precursor while alum is linked to Alzheimer disease [4,7].

Aluminum sulphate and ferric chloride have been traditionally used as primary coagulants in clarification and potabilization processes of raw water. The usage of these coagulants has disadvantages associated with the high acquisition costs, production of high volumes of sludge, changes of water pH and alkalinity, possible relation with Alzheimer and some kinds of cancer problems that could be minimized using natural coagulants that can be extracted from plants and animals. The principal advantages of the implementation of natural coagulants are the following: organic and inorganic turbidity removal, reduction of true and apparent colour, production of easy to deal with sludge, destruction of pathogens, algae and planktons, as well as the elimination of substances imparting odour and flavour. In view of the above, a number of natural materials of plant origin have been used by the local communities in developing countries in water treatment.

The study of phytodisinfective and phytocoagulative activities of some plants in rural Cameroon revealed that, *Garcinia kola* and *Carica papaya* seed, *M. oleifera, J. curcas and Pleurotus tuberregium scherotum* lowered the turbidity and the coliform count of water [8]. The limited knowledge of the exact dosage and mechanism for usage renders them ineffective in competing favourably with widely known synthetic chemicals. It has been established that bitter kola and paw seeds contain antimicrobial chemical substances [9]. It has been reported that the extracts of bitter kola inhibit the growth of bacteria such as *E. coli, Staphylococcus aures, Klebsiella pneumonia, Bacillus subtilis* and *Pseudomonas aeruginosa* [10]. It also inhibited the growth of some *fungi, Candida albicans, Aspergellus niger.* Some of these pathogens are commonly found in unclean water and by extension, bitter kola and paw-paw seeds can be used to treat water. Interestingly, paw-paw seed has the added property of being a coagulant [11]. Water treatment is largely made up of coagulation, filtration and disinfection. This study investigated the combined effect of Bitter kola (*Garcinia cola*) and Paw-paw (*Carica papaya*) seed as biodisinfectants and coagulants in water treatment.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

The bitter kola (*Garcinia kola*) seed and *Carica papaya* were botanically identified and confirmed at the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike. The *Garcinia kola* seeds were dehusked, each seed was cut into small pellets with kitchen knife and the resulting pellets were subsequently dried in an electric oven for 12 h at 40℃. The dried seed pellets were ground to fine powder using manual grinder and then sieved with 10 mm sieve. The powder was used in the extraction process while the remaining powder aliquots were used for phytochemical screening. *Carica papaya* fruits were cut open and the seeds were removed and placed in a bowl. The seed coat was removed by bursting with the aid of a mortar and pestle, followed by vigorous washing to remove debris and produce clean seeds. The cleaned seeds were placed on a foil paper and put in the oven at a temperature of 40℃ for 48 h to dry. The dried seeds were ground using manual grinder into powdered form and properly stored in sealed sterilized polythene for extraction and phytochemicals analysis. Water samples were collected in triplicate from Water Side (Ogbor hill) River in Aba using sterilized plastic containers.

2.2 Qualitative and Quantitative Analysis of Phytochemical Constituents of *Garcinia kola* and *Carica papaya* Seed

Phytochemical tests were carried out to establish the presence of some specific phytochemicals (alkaloids, saponins, flavonoids, tannins and phenols). The chemical tests were carried out with standard specimens using standard procedures to identify the constituents [12,13,14]. In addition, alkaloids were determined using the alkaline precipitation gravimetric method [13]; flavonoids by the Ethyl acetate precipitation method [15]; saponins with the double solvent extraction gravimetric method [13]; phenols with Follins method and tannins by the Follins-Dennis spectrophotometric method [16].

2.3 Preparation of Stock Solutions

The powdered form of *Garcinia kola* (Heckel) and *Carica papaya* (Linn.) were sieved to remove the large particles. 1 g of each powder was mixed with 100 ml distilled water to form 100 ml suspension. The suspension was then mixed thoroughly using a clean magnetic stirrer for 5 min to extract the active component, followed by filtration of the solution through a filter paper to remove solid materials. The obtained stock solutions preserved in a refrigerator at 3℃.

2.4 Microbial Analysis of Water before and after Application of *G. kola* and *C. papaya*

The microbial analysis was performed to determine the microbiological quality of the water sample. These tests which include; the *Faecal Streptococcal count, E. Coli, Staphylococcus* and the estimation of the most probable number (MPN) of Total coliform bacteria were conducted prior to treatment and after the incorporation of the mixed *Garcinia kola and Carica papaya* seed solution into the water sample.

2.5 Determination of Bacterial Load

Bacterial load was determined by direct culture count as total viable count and expressed as the number of colony forming units per unit volume of the water sample. Serial dilution of the water sample was done before plating using the methods given by [17]. Using a sterile syringe, 9 ml each of the diluents (sterile water) was placed into 10 different test-tubes arranged in a rack. The water sample was then shaked to mix and 1 ml was taken using sterile 5 ml syringe and then added into the first test tube in the rack and shaken properly to mix. 1 ml of the water was taken from the first test tube and delivered into the second test tube and mixed. This process was repeated for the 10-test tubes. 0.1 ml aliquot of each dilution 1 to 5 test tubes was then plated on an already solidified nutrient agar. The water sample was spread evenly on the surface of the agar using sterile swab stick, after which the inoculated media was allowed to dry and then incubated at 37℃ for 24 h. After the incubation period, number of colony growths on the agar were counted with colony counter Gallenkamp (model S 301-C) and recorded.

2.5.1 *Staphylococcus* species

The culture was done on nutrient agar medium using pour plate method and was incubated at 37℃ for 24 h. Observed colonies were butyrous opaque and pigmented. The colonies were counted and recorded.

2.5.2 *Streptococcus* species

The isolating and counting of *streptococcus spp* were done on blood agar medium using pour plate method. Incubation was at 37℃ for 24 h. The colonies were transparent surrounded by an area of haemolysis. The colonies were counted and recorded.

2.5.3 *Escherichia coli*

E. coli was confirmed by sub culturing onto Eosin methylene blue agar (EMBA) and incubated at a temperature of 37℃ for 24 h. Growth of dark metallic sheen colonies confirmed the presence of *E. coli*.

2.5.4 Total heterotrophic bacteria

Total heterotrophic bacteria was cultured onto nutrient agar and incubated at a temperature of 37℃ for 24 h. The colonies were counted and recorded.

2.5.5 Total coliform using most probable number (MPN) method

The water sample was thoroughly mixed by inverting the bottle several times. The cap was then removed and 50 ml of water was added to the bottle containing 50 ml of MarConkey broth (double strength), using a 10 ml syringe, 10 ml of water as added to each of the five bottles containing 10 ml of MarConkey broth (double strength). Also, 1 ml of the water was added into each of the 5 bottles containing 5 ml of MarConkey broth (single strength). For the treated water sample, 50 ml of water was added to the bottle containing 50 ml of MarConkey broth (double strength) and 10 ml of water placed into each of the 5 bottles containing 10 ml of MarConkey broth (double strength). The inoculated broths were then incubated at 44℃ for 24 h with the bottles loosely caped. After the incubation period, the results were read and recorded using Cheesbrough standards [18].

2.6 Physico-chemical Analysis of Water Prior and after Application of Mixed Ratio (1:1) of *G. kola* and C*. papaya* Seed Solution

2.6.1 Organoleptic analysis (colour, taste and odour)

Apparent colour of water samples was determined by visual comparison. 100 ml of the water sample was transferred into a pre-cleaned 100 ml beaker. Colour was determined by visual comparison of sample with a colour comparator (Custer Colour Strip). Taste and odour were determined by tasting and smelling the water sample using a panel of ten persons.

The turbidity of the water sample was determined using a mulitmeter analyzer (Hanna H19828). The meter was calibrated with 0.1M KCl solution for conductivity and buffer (4,7 and 9) solutions for pH. The values for temperature, turbidity, pH and conductivity were read on the screen. BOD was determined according to the titrimetric method described by [19]. The Nitrate ion content was determined using CHROMA colorimeter (model 257) and calibrated with standard nitrate solution at 420 nm absorbance. Chloride was determined by [20], 50 ml of the water sample was measured into a conical flask with potassium chromate as indicator and was titrated with 0.02 M silver nitrate until the colour changes to brick red. Determination of Total dissolved solids (TDS) was carried out using a clean evaporating dish, heated to 180℃ for 1 h in a drying oven and cooled in a desiccator. 100 ml of water sample was added. The water sample was stirred with magnetic stirrer and 50 ml was filtered using Whatman no. 1 Filter paper. The total filtrate was transferred into the cooled evaporating dish and evaporated to dryness on a steam bath. The dish and sample were oven-dried at 180℃ for 1 h, cooled in a desiccator and weighed. The cycle of drying, cooling, desiccating and weighing was repeated until constant weight was attained.

2.7 Experiments for Coagulation/ Flocculation and Disinfection

The jar test was used. 10 ml of the various concentrations of mixed (ratio, 1:1) of *Garcinia kola* and *carica papaya* seed solution were measured into a beaker containing 1000 ml of the sample water. The solutions were mixed rapidly for 2 min; followed by 10 min of gentle mixing using glass rod to aid in coagulant formation. The suspensions were left to stand without disturbance for 1 h [21]. The supernatants formed were decanted and subjected to microbial analysis and physicochemical analysis.

2.8 Statistical Analysis

Mean and standard deviation of triplicate values were calculated and the results were analyzed using single factor analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

The results of the qualitative phytochemical screening of *Garcinia kola* and *Carica papaya* seeds show the presence of some important phytochemicals. From the result, it was found that the seeds contained phytochemicals such as alkaloids, tannins, saponins and flavonoids as shown in Table 1.

Similar work on the phytochemical screening of *G. kola* seeds revealed the following composition: flavonoids 1.88 – 6.10 mg/100 g; saponins 12.00 – 1.23 mg/100 g; tannins 0.31-0.41 mg /100 g; alkaloids 0.40 – 0.30/100 and phenols 0.1-0.09 mg/100 g [22]. Another study concluded that *G. Kola* showed a high level of saponins (2.471%), flavonoids (2.041%) and cardiac glycosides (3.421%) and that alkaloids and tannins were present in considerable amounts of 0.647 and 0.34%, respectively [23]. But that phenol was present in negligible amount (0.147%). Other authors obtained a tannin composition of 5.08 ±0.02, flavonoid 0.93 ±0.03, alkaloid 5.13 ±0.67 and saponin 2.54±0.01% [24]. In another study, the phytochemical composition of the aqueous extract of *C. papaya* seeds was analyzed and values obtained were; alkaloids 1.22 ±0.060, flavonoids 0.34 ±0.020, tannins 0.77 ±0.010, saponins 0.42 + 0.001 and phenols 0.12 ±0.002% [25]. A study of *C. papaya* seeds observed the following phytochemical composition: phenol 0.13, alkaloid 0.51, flavonoid 0.83, tannin 0.30 and saponin 1.31% [26].

Flavonoids provide anti inflammatory action [27]. Alkaloid and tannin contents were significantly higher (P = .05) in *Carica papaya* compared to *Garcinia kola* while flavonoids and phenol content were significantly higher (P = .05) in *Garcinia* kola. Tannins are metal chelators and can form complexes with macro molecules. Through this process essential substrates co-factor and enzymes of micro-organism are depleted leading to cell death. This accounts for the antimicrobial activity against bacteria and fungi.

Phenols and phenolic compounds have been extensively used in disinfections and it remains the standard with which other bactericides are compared [28].

Table 2 shows mean ($\pm$SD) physicochemical and microbial parameters of water sample before treatment with the seed solutions. The raw data obtained from the surface water at Ogbor Hill River showed a very high total heterotrophic bacterial population and high faecal indicator bacteria, suggesting the presence of pathogens this is as a result of human activities like abattoir and pig breeding around the environs of the river.

The result in the Table 3 shows that the temperature of the water sample was not significantly affected following coagulation with *Garcinia kola* and *Carica papaya* seed extract. The mean temperature of water sample before coagulation was $30.5 \pm 0.10℃$, on addition of the mixed extract of both seeds in the ratio of one is to one, mean temperature had a range of 30.00 ± 0.10 – $30.50 \pm 0.10℃$. The mixed *Garcinia kola* and *Carica papaya* seed extract has no significant effect (*P* = .05) on temperature of water sample. The pH of the water sample was generally, slightly affected following coagulation with mixed extract of *Garcinia kola* and *Carica papaya* seed solutions. On addition of various concentration dosages of mixed *Garcina kola* and *Carica papaya* seed extract in water sample, pH of water sample decreased from 7.4 ± 0.20 to 6.97 ± 0.11. The slight decrease in pH following treatment with mixed extract of *Garcinia kola* and *Carica papaya* seed may be due to hydrogen ions from the extract, which balanced the hydroxide ion in the water sample.

This is in line with previous study which has shown that the use of plant seed extract does not cause any significant change in the pH [8,11,21]. The amount of total dissolved solids (161.54 ±1.13) decreased with increase in the concentration of the mixed *Garcinia kola* and *Carica papaya* extract. At 1% concentration, TDS was reduced to 130.83 ± 0.92 mg/L while at 2%, 3%, 4% and 5% it was reduced to 121.30 ± 0.17, 128.50 ± 0.26, 104.20 ± 0.54 and 109.40 ± 0.82 mg/L respectively. Results indicate that mixed *Garcinia kola* and *Carica papaya* extracts significantly reduced (*P* = .05) TDS of water samples and exhibited maximum TDS reduction at 4% extract concentration. At this optimum dose, mixed *Garcinia kola* and *Carica papaya* seed extract showed 35.5% TDS removal. At 5% concentration dose, TDS tends to increase which could be as a result of organic particles from the coagulants.

The conductivity of the water samples had slight decreases with increase in the dosage of *Garcinia kola* and *Carica papaya* seed extract. The mean conductivity of water sample before coagulation was 221.4 ± 0.35 μScm^{-1}. On addition of the mixed extract of *Garcinia kola* and *Carica papaya*, mean conductivity had a range of 211.00 ± 0.10 μScm^{-1} - 218.70 ± 0.35 μScm^{-1}. The mixed *Garcinia kola* and *Carica papaya* seed extract has no significant effect (*P* > .05) on conductivity of water sample.

Table 1. Quantitative phytochemical analysis of *Garcinia kola* and *Carica papaya* seed

Samples	% Alkaloid	% Flavonoid	% Tannin	% Saponins	% Phenols
Garcinia kola	2.11 ± 0.04	2.16 ± 0.03	0.14 ± 0.02	0.34 ± 0.04	1.65 ± 0.01
Carica papaya	2.67 ± 0.02	0.49 ± 0.03	0.35 ± 0.02	0.23 ± 0.03	0.66 ± 0.02

Data represent the mean ± standard deviation of triplicate samples

Table 2. Mean (±SD) physicochemical and microbial parameters of water sample before treatment with mixed ratio (1:1) of *Garcinia kola* and *Carica papaya* seed solution

Parameters	Value
Colour	Brownish
Taste	Objectionable
Odour	Objectionable
Temperature	30.50 ± 0.10
pH	7.40 ± 0.20
TDS (mg/L)	161.54 ± 1.13
Turbidity (NTU)	31.64 ± 0.08
Conductivity (*μ*S/cm)	221.40 ± 0.35
BOD (mg/L)	5.87 ± 0.03
Chloride (mg/L)	0.28 ± 0.02
Nitrate (mg/L)	248.60 ± 10.27
Nitrite (mg/L)	1.86 ± 0.04
Total coliform (MPN/ml)	12.00 ± 1.00
E. coli (CFU/ml)	767.00 ± 1.00
Fecal streptococcus (CFU/ml)	1033.00 ± 1.15
Staphyl. aureus (CFU/ml)	1567.00 ± 2.52
Total heterotrophic bacteria (CFU/ml)	TNTC

TNTC = CFU/ml > 10,000; NTU = Nephelometric turbidity units

Table 3. Mean (±SD) physicochemical parameters of water sample after treatment with mixed ratio (1:1) of *Garcinia Kola* and *Carica Papaya* seed solution

Physico chemical parameters	Coagulant concentrations					
	1%	2%	3%	4%	5%	Blank
Temperature	30.00±0.20	30.10±0.10	30.00±0.20	30.10 ± 0.10	30.00 ± 0.20	30.50±0.10
pH	7.21 ± 0.26	7.25 ± 0.35	7.00 ± 0.17	6.97 ± 0.11	6.97 ± 0.16	7.40 ± 0.20
Residue TDS (mg/L)	130.83 ± 0.92	121.30 ± 0.17	128.50 ± 0.26	104.20 ± 0.54	109.40 ± 0.82	161.54 ± 1.13
Turbidity (NTU)	18.14 ± 0.02	15.05 ± 0.02	10.18 ± 0.01	12.06 ± 0.02	14.48 ± 0.02	31.64 ± 0.08
Conductivity (*μ*S/cm)	218.70 ± 0.10	216.00 ± 0.20	214.30 ± 0.30	213.00 ± 0.20	211.00 ± 0.10	221.40 ± 0.35
BOD (mg/L)	3.47 ± 0.12	3.30 ± 0.10	2.51 ± 0.15	2.60 ± 0.20	2.80 ± 0.10	5.87 ± 0.03
Nitrate (mg/L)	230.40 ± 0.36	208.74 ± 2.82	198.00 ± 0.20	150.60 ± 0.30	144.20 ± 0.27	248.60 ± 0.27
Nitrite (mg/L)	0.24 ± 0.02	0.22 ± 0.03	0.20 ± 0.02	0.13 ± 0.01	0.1 0 ± 0.02	1.86 ± 0.04
Chloride (mg/L)	0.26 ± 0.01	0.22 ± 0.02	0.20 ± 0.02	0.20 ± 0.01	0.1 8 ± 0.06	0.28 ± 0.02

Table 4. Mean total bacterial count of water after treatment with mixed *Garcinia kola* and *Carica papaya* seed extract

Microbial count	1 %	2 %	3 %	4 %	5 %
Total coliform (MPN/ml)	7.00 ± 0.50	6.00 ± 1.00	5.00 ± 1.00	2.00 ± 1.00	2.00 ± 1.00
E. coli (CFU/ml)	4.00 ± 0.50	4.00 ±0.53	3.00 ± 0.10	3.00 ± 0.20	3.00 ± 0.10
Fecal strept (CFU/ml)	9.00 ± 0.10	7.00 ± 0.50	6.00 ± 0.20	4.00 ± 0.53	2.00 ± 1.00
Staphyl. aureus (CFU/ml)	9.33 ± 1.00	8.00 ± 0.15	7.00 ± 0.53	5.00 ± 0.20	3.00 ± 0.53
Total heterotropic bacteria (CFU/ml)	58.00 ± 2.00	55.00 ± 1.00	50.00 ± 1.00	45.00 ± 0.50	30.00 ±1.00

The mean BOD of water sample before coagulation was 5.87 ± 0.03 mg/L and on adding various doses of mixed *Garcinia kola* and *Carica papaya* seed extract, the BOD had a range of 2.51 ± 0.15 - 3.47 ± 0.12 mg/L. The results indicated that mixed *Garcinia kola* and *Carica papaya* extracts significantly reduced (P = .05) BOD of water samples and exhibited maximum BOD reduction at 3% extract concentration. The mixed extract removed 57.21% of the BOD. Above this optimum dosage, BOD increased.

The nitrate ion present in the water sample were reduced on increase in the dosage of the mixed *Garcinia kola* and *Carica papaya* seed extract. Mean nitrate ion of the water sample before coagulation was 248.60 ± 0.27 mg/L and on addition of various doses of mixed *Garcinia kola* and *Carica papaya* seed extract, the nitrate ion had a range of 144.20 ± 0.27 - 230.40 ± 0.36 mg/L. The result indicated that mixed *Garcinia kola* and *Carica papaya* extracts significantly reduced (P = .05) nitrate ion of water samples and exhibited maximum reduction at 5%. The mixed *Garcinia kola* and *Carica papaya* seed extract removed 42.00%.

The nitrite ion present in the water sample was reduced on increase in the dosage of mixed *Garcinia kola* and *Carica papaya* seed extract. On addition of the different doses of mixed *Garcinia kola* and *Carica papaya* seed extract, the nitrite ion had a range of 0.10 ± 0.02 - 0.24 ± 0.02 mg/L. The result indicated that mixed *Garcinia kola* and *Carica papaya* extracts significantly reduced (P = .05) nitrite ion of water samples and exhibited maximum reduction at 5%. The mixed *Garcinia kola* and *Carica papaya* seed extract removed 94.62% of nitrite ion from the water sample.

The chloride ion in the water sample was not significantly affected (P >.05) following coagulation with *Garcinia kola* and *Carica papaya* seed extract. The mean chloride ion of water sample before coagulation was 0.28 ± 0.02 mg/L but on addition of the mixed *Garcinia kola* and *Carica papaya* extract, mean chloride ion had a range of 0.18 ± 0.06 – 0.26 ± 0.01℃ on increase in concentration. Mixed extract of both seeds in the ratio of 1:1 had similar effect (P > .05) on the water sample.

The mixed *Garcinia kola* and *Carica papaya* seed solutions at different levels reduced the turbidity of the water sample, with 1% concentration reducing the turbidity to 18.14 ± 0.02 NTU whereas 2%, 3%, 4% and 5% concentration reduced the turbidity to 15.05 ± 0.02 NTU, 10.18 ± 0.01 NTU, 12.06 ± 0.02 NTU and 14.48 ± 0.02 NTU respectively. Mixed *Garcinia kola* and *Carica papaya* extracts significantly reduced (P = .05) turbidity of water samples and exhibited maximum turbidity reduction at 3% extract concentration. At this optimum dose, 67.83% turbidity was removed.

The mean total bacterial count of water after treatment with mixed *Garcinia kola* and *Carica papaya* seed extract is shown in Table 4.

The results indicated that treatment of water sample with mixed *Garcinia kola* and *Carica papaya* solution showed antimicrobial efficiency of 41.67 – 83.33% for Total coliform, 47.85 – 60.89% for *E. coli*, 12.87-83.33% for *Fecal streptococcus*, 40.46 – 83.33% for *staphylococcus aureus* and 50.43 – 74.36% for Total heterotrophic bacteria. As the concentration of the *Garcinia kola* and *Carica papaya* solution increased from 1- 5%, the inhibition of the microbial growth by the solutions increased i.e. the extracts worked in a dose dependent manner. Plant coagulant seeds are rich in nutrient which enter into the water and possibly serves as a substrate for bacterial re-growth [5].

4. CONCLUSION

This study has successfully revealed that the seed extracts of mixed *Garcinia kola* and *Carica papaya* seed solution possesses antimicrobial properties against total coliform, *E. coli, streptococcus spp., staphylococcus aureus* and total heterotrophic bacteria. These extracts are natural antimicrobial agents and coagulant with potentials in controlling bacteria which causes water borne diseases and reduces suspended particles in raw water. It can be concluded that *Garcinia kola* and *Carica papaya* seed can be used in treating water.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pritchard M, Mkandawire T, Edmonson A, O'nell JG, Kululuga G. Potential of using plant extracts for purification of shallow

well water in Malawi. Physics and Chemistry of the Earth. 2009;34:799-805.

2. Muyibi SA, Okafor CA. Coagulation of low turbidity surface water with *Moringa oleifera* seeds. Int. Journal of Environmental Studies. 1995;48:263-272.
3. McConnachie GL. Field trial of appropriate hydraulic flocculation processes. Water. Res. 1999;33(6):1425-1434.
4. Yongabi KA. Studies on the potential use of medicinal plants in water and wastewater purification. Proceedings of an E-Seminar Organized by the International Organization of Biotechnology; 2004.
5. Ghebremichael KA. Moringa and pumice as natural alternative materials for drinking water treatment. PhD KTH Land and Water Resources Engineering; 2004.
6. Kebreab AG, Gunaratna KR, Henrickson H, Brumer H, Dalhammar G. A sample purification activity essay of the coagulation protein from *Moringa oleifera* seed. Water Res. 2005;39:2338-2344.
7. Zhang J, Livo Y, Yang H. A preliminary study of cactus as coagulant in water treatment. Process Biochem. 2006;41(3): 730-733.
8. Yongabi KA, Lewis DM, Harris PL. Application of phytodisinfectants in water purification in Rural Cameroon. African Journal of Microbiology Res. 2011;5(6): 628-635.
9. Eleyinmi AF, Adebowale YA, Oluwalana IB, Ajisafe OJ, Akintomide TF. Effect of dietary inclusion of *Garcinia kola*, *Gongronema latifolium and vernonia amygdalina* on the nutritional quality of a complementary diet. Research Journal of Biological Sciences. 2006;1(1–4):43–49.
10. Arekemase MO, Badandoko AM, Ojo KKM, Elizabeth AA, Kamoldeen AA. Antimicrobial effects of *Garcinia kola* (bitter kola) on some selected pathogens from University of Ilorin teaching hospital Ilorin, Nigeria. Asian Economic and Social Society. 2012;2(4):157–169.
11. Megersa M, Beyene A, Ambelu A, Woldeab B. The use of indigenous plant series for drinking water treatment in developing countries. Journal of Bio-diversity and Environmental Sciences (JBES). 2014;5(3):269-281.
12. Sofowara A. Medicinal plants and traditional medicine in Africa. Ibadan: Spectrum Books Ltd; 1993.
13. Harborne JB. Phytochemical methods: A guide to modern techniques of plant analysis. 3rd Ed. London: Chapman and Hall; 1998.
14. Trease GE, Evans WC. Phytochemical screening. In: Textbook of Pharmacognosy, Trease, GE, Evans WC, editors. 10th Edn. London: Bailiere Tindal Limited; 1989.
15. Bohm MK, Kocipai A. Flavonoids composition and uses. Washington: Smithsonian Institution Press; 1994.
16. Pearson D. The chemical analysis of foods. 17th ed. London: Churchill Livingstone; 1976.
17. Amadi ES, Ayogu TE. Microbiology laboratory manual II. Enugu: Cresco Printing and Publishers; 2005.
18. Cheesbrough M. District laboratory practice in tropical countries, part 2. Cambridge: Cambridge University Press; 2000.
19. APHA. Standard methods of the examination of water and waste water. 21st Ed. Washington D.C: American Public Health Association; 2005.
20. IS. Experiment on Determination of Chloride. Indian Standards 3025 (part 32) – Reaffirmed; 2003.
21. Ndabigengesere A, Narasiah KS, Talbot BG. Active agents and mechanism of coagulation of turbid waters using *Moringa oleifera*. Water Res. 1995;29(2):703-710.
22. Alaje DO, Owolabi KT, Olakunle TP, Oluoti OJ, Adetuberu IA. Nutritional, minerals and phytochemicals composition of *Garcinia cola* [Bitter cola] and *Aframomum melegueta* [Alligator pepper]. Journal of Environmental Science, Toxicology and Food Technology. 2014;8(1):2319-2402.
23. Adesuyi AO, Elumm IK, Adaramola FB, Nwokocha AGM. Nutritional and phytochemical screening of *Garcinia kola*. Advance Journal of Food Science and Technology. 2011;4(1):9-14.
24. Omeh YN, Onoja SO, Ezeja MI, Uchendu WC, Okorie E, Raymond M. Quantitative phytochemical, proximate analysis and hypolipidemic effect of *Garcinia kola*. British Journal of Medicine & Medical Research. 2014;4(36):5770-5778.
25. Okoye EI. Preliminary phytochemical analysis and antimicrobial activity of seeds of *Carica papaya*. Journal of Basic Physical Research. 2011;2(1):66-69.

26. Chukwuka KS, Iwuagwu M, Uka UN. Evaluation of nutritional components of *Carica papaya* L. at different stages of ripening. Journal of Pharmacy and Biological Sciences. 2013;6(4):13-16.
27. Okwu DE. Evaluation of the chemical composition of medicinal plants belonging to *Euphorbiaceae* Pak. Vet. Journal. 2001;14:160.
28. Oakenful D. Saponins in food – A review. Food Chemistry. 1981;16:19-40.

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