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Comparative study of turbidity removal efficiency of green pea *(Cicer arietinum)* seed and pod extract for turbid water treatment

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Abstract
Natural coagulants are considered affordable and efficient substitutes to chemical coagulants for use in water treatment. The study investigated the turbidity removal efficiency of pea seed and pod extracts from surface water. Chemical and proximate analyses of pea seed and pod were evaluated. Optimum values of coagulant dose, pH and stock solution concentrations were determined using jar test. Turbidity removal efficiencies and residual turbidity of the coagulant were also evaluated. The highest turbidity removal efficiency was found to be 98% and 97% at 10% w/v stock solution concentration of the pea seed and pod extract respectively. The optimum pH suitable for coagulation of surface was found to be 6.8 and 6.6 at 10% w/v stock solution of pea seed and pod extract respectively. The pea seed and pod extract were found to be most efficient in removing turbidity from surface water at 10% (w/v) stock solution with optimum dose of 1600mg/L. The p-value was found to be 0.99, 0.0156 and 0.33 for Turbidity removal efficiency, pH and Residual turbidity of pea seed and pod respectively. Pea seed and pod turbidity removal efficiencies are statistically insignificant, but their pH and Residual turbidity values are statistically significant. The findings in this study suggest that both the Pea pod and Pea seed extract are effective in water coagulation, but pea seed extract is more effective in drinking water coagulation, while pea pod extract was cheaper and readily available.

Keywords: *Turbidity, Coagulation, Green Pea.*

Introduction

In developing countries, people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water as they lack the knowledge of proper drinking water treatment and also cannot afford the high cost of chemical coagulants. To overcome these chemical coagulant problems, it is necessary to increase the use of natural coagulants for drinking water treatment (Mangale et al., 2012). The history of the use of natural coagulant for the removal of turbidity is long. It was found that natural coagulant worked better with high turbid water. Highest turbidity reduction efficiency of about 78% was noticed. Influence of the pH on the system was found to be significant on turbidity removal (Madhavi et al., 2013).

Natural organic polymers have been used for more than 2000 years ago in India, Africa, and China as effective coagulants and coagulant aids at high water turbidities. They may be manufactured from plant seeds, leaves and roots. Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification (Madhavi et al., 2013 and Kawamura, 1991). Cicer arietinum (green pea) is a legume of the subfamily Faboideae of the flowering plant family (Saha et al., 2014). It is known as gram or Bengal gram or Egyptian pea. Ancient people associated pea with medical uses. It is widely grown in India, Turkey, and Nigeria. It is an annual plant with a life cycle of one year.

The immature peas are used for vegetable. Fresh, canned or frozen matured peas are used as dry peas or slit peas. It is starchy, high in fiber, vitamins, minerals, proteins and lutein (Makki, 2017)

Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification (Madhavi et al., 2013) and (Kawamura, 1991).

Saha et al., (2014) reported that the presence of bioactive compounds in pea pod is equal to that present in pea cotyledon or seed. This shows the possibility of Pea seed and pod to act as coagulant.

The research entails the comparative assessment of the efficiency of pea seed and pod as coagulant in surface water treatment.

Materials and Method

Sample collection and preparation

The dried pod and seed were separately grounded to fine powder using mill of Binatone BLG-452 D Conventional Blender/ Grinder BLG-450. The ground powders were then sieved through a 210µm sieve. The extraction was in accordance with Aweng et al., (2012), but was mixed with a different mixer: Crude extracts was prepared by using 500ml of distilled water to 50g of the prepared powder, which was mixed by a British made (RPM=1400, HP=1/86, watt=8.6) stirrer for 60min and left to settle for 20 minutes to make 10% stock solution of the pea seed and extract. This was kept refrigerated to prevent any ageing effects Solutions were shaken vigorously before use.

Results and Discussion

Proximate analysis of pea seed and pod

Table 1: Proximate analysis of pea seed and pod samples

SAMPLE REPLICATION	SAMPLE IDENTIFICATION	% ASH	% MOIST	% CP	% CF	% EE	% CHY	% NFE
1	PEA SEED SAMPLE (A)	7.60	4.00	8.59	20.10	1.15	33.58	62.74
2	PEA SEED SAMPLE (B)	7.53	4.38	9.11	19.68	0.95	32.80	62.57

SAMPLE REPLICATION	SAMPLE IDENTIFICATION	% ASH	% MOIST	% CP	% CF	% Ee	% CHY	% NFE
1	PEA POD SAMPLE (A)	7.62	3.98	8.49	20.15	1.10	33.38	62.64
2	PEA POD SAMPLE (B)	7.43	4.33	9.06	19.77	0.97	32.90	62.77

Pea pod proximate analysis

%ASH: % Ashing; %MOIST: % moisture content; % CP: % Crude protein content; % CF: % Crude fibre content; % Ee: % Fat content; % CHY: % Carbohydrate content; % NFE: % Nitrogen Free Extra content.

Proximate analysis of pea seed and pod

Complete standard proximate procedure analyses of the pea seed and pod was done in Department of Animal Science and also in Biochemistry Department, Bayero University Kano (Makki, 2017)

Preparation of stock solution of for synthetic turbid water

The stock suspension was prepared as described by Chidinand Patil et al., (2015). 50 grams of Bentonite kaolin was added to 500ml of water allowed to soak for 24 hours to make the stock solution. The stock solution was diluted with 500ml of distilled water which was used to prepare water samples of high turbidity (416 NTU).

Jar test operations and analytical methods

Standard procedures for Jar test according to Singh, (2014); Asfaruzzaman et al., (2011) was followed.

Statistical data analyses

R programmers, Microsoft excel and SPSS were used in data analysis to compare the results of the pea seed and pod.

Table 2: t-Test: Proximate analysis of result values for pea seed and pod (sample As) assuming unequal Variances

	Variable 1	Variable 2
Mean	19.68	19.62286
Variance	484.2813	482.636
Observations	7	7
Hypothesized Mean Difference	0	
Df	12	
t Stat	0.004862	
P(T<=t) one-tail	0.4981	
t Critical one-tail	1.782288	
P(T<=t) two-tail	0.996201	
t Critical two-tail	2.178813	

Table 3: t-Test: : Proximate analysis of result values for pea seed and pod (sample Bs/replicate)Assuming Unequal Variances

	Variable 1	Variable 2
Mean	19.57429	19.60429
Variance	475.9764	480.003
Observations	7	7
Hypothesized Mean Difference	0	
Df	12	
t Stat	-0.00257	
P(T<=t) one-tail	0.498997	
t Critical one-tail	1.782288	
P(T<=t) two-tail	0.997994	
t Critical two-tail	2.178813	

Table 1, shows the presence of crude protein which is the Aspartic/Glutamine Protein (amino acid) as the active agent having phytodisinfectant/antioxidant, phytocoagulant softening property in water purification.

Crude protein content of pea seed was slightly above that of pea pod, showing that the Pea seed has higher possibility of coagulation effect.

The p-value from table 2 and 3 was found to be 0.99, this shows null hypothesis, meaning that the chemical constituents of pea seed and pod are statistically insignificant (i.e there is no significant difference between pea seed and pod chemical constituents).

Makki (2017) finds similar result that Aspartic/Glutamine Protein was the main chemical constituent responsible for coagulation in Peas.

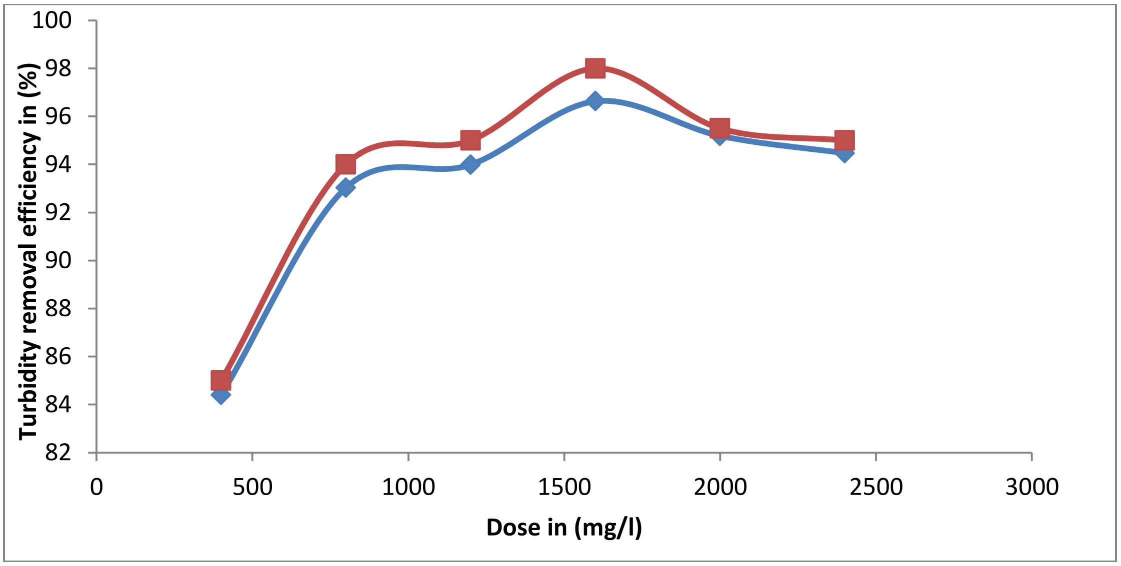

Figure 1: Turbidity removal efficiency versus dose of pea seed and pod extracts at 10% stock solution

Table 4: t-Test: Turbidity removal efficiency values of Pea seed and pod Assuming Unequal Variances

	Variable 1	Variable 2
Mean	92.95167	93.75
Variance	19.01218	20.175
Observations	6	6
Hypothesized Mean Difference	0	
Df	10	
t Stat	-0.31238	
P(T<=t) one-tail	0.380583	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.761166	
t Critical two-tail	2.228139	

The highest turbidity removal efficiency was 98% and 96.63% for the 10% stock solution of pea seed and pod extract respectively. Optimum dose for the 10% stock solution of pea seed and pod extracts was 1600mg/l for both.

This result can be compared with Cassia alata with coagulation activity of 93% (Aweng et al., 2012), water melon seed of 88% (Muhammad et al., 2015) and Moringa oleifera seed extract of 94% (Bichi, 2013), Cicer arietinum (pea seeds), and Dolichos lablab with highest removal efficiency of 96%. (Asfaruzzaman et al., 2011).

The result shows the similarity between the pea pods and seed. The reduction in the coagulation activity in doses above in 800, 1600 dose of Pea seed and pod extract for high turbid synthetic water could be due to the coagulants that remained in excess of the optimum coagulant dose.

The increase in residual turbidity after the optimum point could also be due to increase in plant chlorophyll concentration in water (Kihampa et al., 2011).

The reduction in the coagulation activity in doses above after optimum value is reached for the high turbid water could be due to the coagulants that remained in excess of the optimum coagulant dose. The increase in residual turbidity after the optimum point could also be due to increase in plant chlorophyll concentration in water (Makki, 2017)

Ahmed et al., (2010) shows that there were many parameters that affect coagulation performance (and hence turbidity removal) and that include the amount and type of particulate material, the amount and composition of natural organic matter (NOM), and chemical and physical properties of the water. The common parameters are: coagulant type, dose and pH (Yan et al., 2008 and Uyak, 2007). Many researches have shown that natural organic matter reacts or binds with metal ion coagulants and that coagulant dosage is determined by NOM-metal ion interaction and not particle-metal ion interaction (Matilainen et al., 2002).

Table 4 shows that the p-value was found to be 0.76, this shows null hypothesis, meaning that the turbidity removal efficiency values for pea seed and pod are statistically insignificant (i.e there is no significant difference between the pH values).

pH affects the solubility and the effectiveness of coagulation. So, the investigation is crucial.

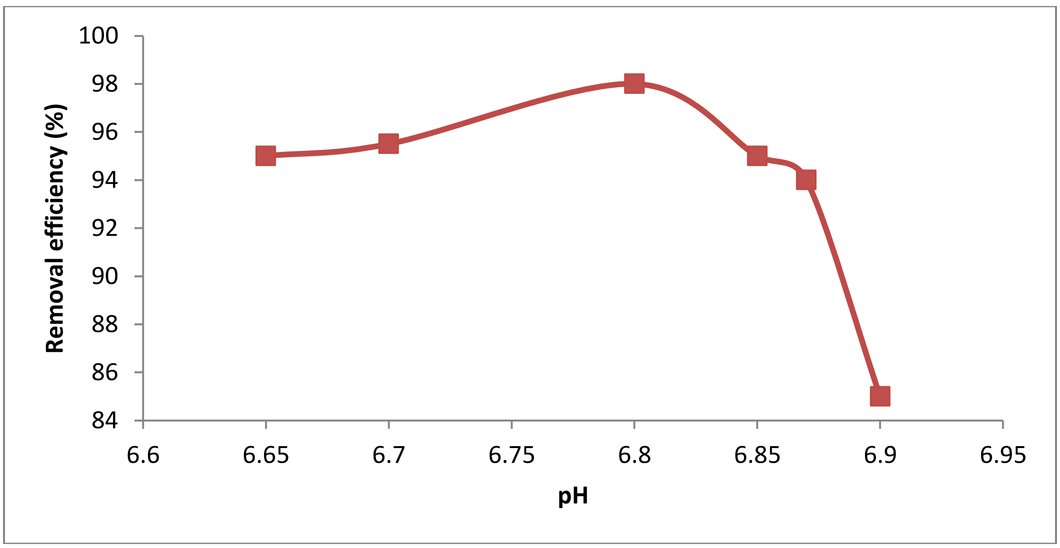

Figure 2 Shows that the pH increases with increases in removal efficiency at the beginning, and then later diminishes when optimum pH was reached at 6.8

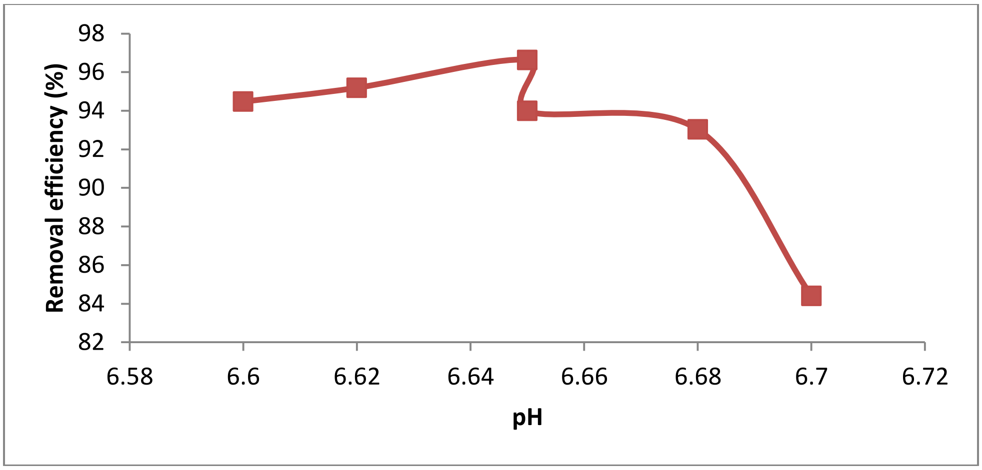

Figure 3: Turbidity removal efficiency versus pH at 10% stock solution of pea pod extract

Figure 3 Shows that the pH increases with increase in removal efficiency at the beginning, and then later diminishes when optimum pH reached at 6.6 same as above.

It was observed that the optimum pH found for both 10% stock solutions of pea seed and pod extract were within the range of acceptable drinking water standard, only a slight deviation between the pH values is seen which is considered insignificant.

Chidanand et al., (2015) found that there is no significant change in pH due to natural coagulants. It is changing in decimal values so it is considered as almost negligible.

Sunita et al., (2014) also found that that both natural coagulants produce appreciable reduction of turbidity at 6-8 pH and it declined at 10 to 12. Chidanand et al., (2015) argued that there was no direct influence of pH on turbidity, although his research was specific on wastewater.

pH VERSUS DOSE OF PEA POD EXTRACT

The initial pH values of the prepared synthetic water was 7.0

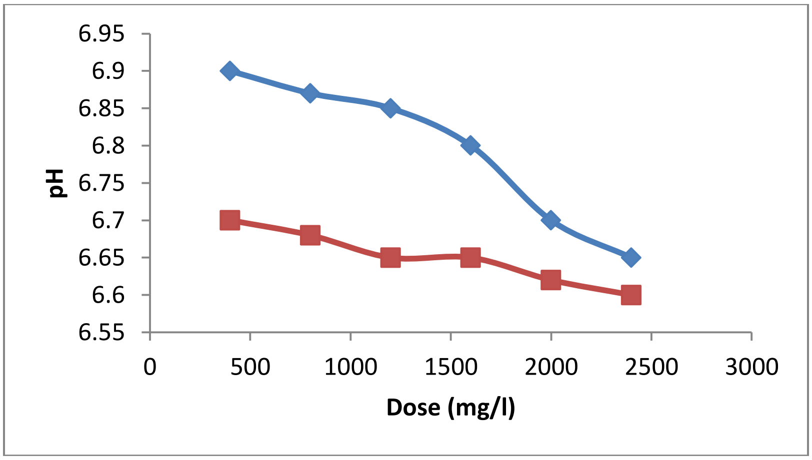

Figure 4: pH values versus dose (mg/L) of pea seed and pod at 10% stock solution concentration

Table 5: t-Test: pH values for pea seed and pod Assuming Unequal Variances

	Variable 1	Variable 2
Mean	6.65	6.795
Variance	0.00136	0.00995
Observations	6	6
Hypothesized Mean Difference	0	
Df	6	
t Stat	-3.33974	
P(T<=t) one-tail	0.007808	
t Critical one-tail	1.94318	
P(T<=t) two-tail	0.015617	
t Critical two-tail	2.446912	

High turbid water was treated with various doses of the pea seed extract filtrates, the pH values changed as shown in figure 4.

There is a slight difference between pH of Pea seed and that of Pea pod.

When the prepared high turbid water was treated with various doses of the pea pod extract filtrates, the pH values changed as shown in figure 4.

Musa (2016) discovered a similar pH reduction while treating water with *Poliostigma thonningischum* and *Tamarinds india* L. leafs extract.

Sethupathy (2015) discovered a similar pH reduction while treating water with Moringa oleifera seed powder: The pH was observed in alkaline nature after treatment with Moringa seed powder. This was confirmed by the work of Jodi et al., (2012).

Table 5 shows that the p-value was found to be averagely 0.0156, the hypothesis is that the pH values for pea seed and pod are statistically significant (i.e. there is significant difference between the pH values).

Residual Turbidities Versus Dose

The initial turbidity of the synthetic turbid water was made constant which is 416NTU.

Table 6: Residual turbidity versus dose for 10% stock solution of pea seed and pod extract

Dose (ml)	Residual turbidity of the samples using 10% stock solution of pea seed extract (NTU)	Residual turbidity of the samples using 10% stock solution of pea pod extract (NTU)	WHO (2019) Standard Turbidity in NTU
2	55	66	25
4	17	29	25
6	10	25	25
8	6	14	25
10	11	20	25
12	13	23	25

Table 6: t-Test for residual turbidity of pea seed and pod Assuming Unequal Variances

	Variable 1	Variable 2
Mean	18.66667	29.5
Variance	329.8667	345.1
Observations	6	6
Hypothesized Mean Difference	0	
Df	10	
t Stat	-1.0214	
P(T<=t) one-tail	0.165569	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.331138	
t Critical two-tail	2.228139	

Table 6 showed that residual turbidity was slightly above 5NTU for both pea seed and pod extracts. The p-value was 0.33 this shows that the residual turbidity values for pea seed and pods are statistically significant. Asfaruzzaman, (2011) found that pea seed reduced turbidity to 5.9, 3.9, and 11 NTU, from 100 NTU after dosing and filtration. This indicates that pea seed has higher potential in water coagulation than pea pod.

Conclusion and Recommendation

The findings showed that both pea seed and pod contain Aspartic/Glutamine Protein (amino acid) as the active agent having phytodisinfectant/antioxidant, phytocoagulant softening property in water purification. The highest turbidity removal efficiency was found to be 98% and 97% at 10% stock solution of pea seed and pod extracts respectively, the optimum pH suitable for coagulation of the surface water at 10% stock solution of pea seed and pod extract were found to be 6.8 and 6.7 respectively, the optimum dose was found to be 1600 mg/L at 10% (w/v) stock solution for both pea seed and pod extract. Both the Pea seed and pod are effective in drinking water coagulation, but pea seed extract is more effective in coagulation, while pea pod extract is more available and economic wise.

In order to improve on the application of pea seed and pod extract in water treatment, certain questions still need to be answered. The studied material can be used for turbidity removal, perhaps for small communities or households, in developing countries. The following are some of the areas requiring further investigations; the mode of attack of the extract on the microbes, the effect of settling time of coagulants on coagulation property of pea seed pod extract, the use of pea seed and pod extract in the removal of bacteria (E-Coli) from turbid waters, the use of pea seed and pod extract in waste water treatment.

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