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The Potential of Using Citrullus Lanatus, Moringa Oleifera and Hibiscus as Natural Coagulant for Wastewater Treatment

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Abstract

Natural coagulant wastewater treatment methods are gaining popularity due to their environmentally friendly method which can reduce the effluent treatment footprint and lack of toxicity compared to chemical coagulant. Hence, this research evaluated the potential of the moringa oleifera, hibiscus seeds and citrullus lanatus as a natural coagulant. All of these plant was used for the treatment of leachate industrial wastewater samples. Experimental tests were performed to evaluate the efficiency of natural coagulant based on pH reduction and turbidity removal. The studies was run by jar test experiment with two methods which are run based on different ratio of coagulant with alum and speed of rotation of jar test in range between 10-40 rpm. Results demonstrated that the hibiscus shows the highest turbidity removal and pH reduction percentage at 10 rpm speed of rotation which are 24.2% and 99.6% respectively. Following that, at 0.1g of moringa oleifera coagulant dosage, there was a significant decrease in both parameters, with an average turbidity and pH reduction percentage of 13.6% and 3.5% respectively. Hence the lowest the speed of rotation, the effective of coagulant decreases and the lower amount of natural coagulant dosage used the higher the percentage turbidity and pH reduction.

1. Introduction

In Malaysia, water quality and clean water as well as access to water in general is a major problem. This is because Malaysia is experiencing rapid urbanization and population growth. This rapid growth leads to an increased demand for water and spiked levels of water pollution. Sewage embodies organic matter, suspended solids, nutrients, and pathogenic microorganisms, are the cause the water become more contaminate. In wastewater treatment, coagulation has been practiced since earliest times and the main objective is to remove colloidal impurities hence also removing turbidity from the water. Coagulant is a chemical used that is added to the water to withdraw the forces that stabilizes the colloidal particles and causing the particles to suspend in the water. Once the coagulant is introduced in the water, the individual colloids must aggregate and grow bigger so that the impurities can be settled down at the bottom of the beaker and separated from the water suspension. Eco-friendly coagulants, which are widely accessible and inexpensive, can be used as an alternative to other traditional coagulation techniques [1].

To reduce it, coagulation-flocculation treatment that used an environmentally friendly coagulant could result in improved effluent treatment as well as benefits from the recovery and recycling of water to the plant with minimal treatment [2]. Therefore, this experiment was designed to remove pollutants from wastewater using three different natural coagulants. This research evaluated the potential of the moringa oleifera, hibiscus seeds and citrullus lanatus as a natural coagulant by using the leachate water sample from the industry wastewater. Moringa oleifera seed is a natural plant with active bio-coagulate compounds that can be used for water clarification because it reduces the use of chemical-based coagulants. Watermelon is a popular summer plant in the sub-Sahara, and its seeds, like other indigenous seeds may be served as excellent water filters due to their adsorbent qualities. Next, according to a nutritional study of Hibiscus, the seeds have the highest protein content (31.02%) when compared to the flower and calyces, and the seed could be used as a potential source of proteins. The specific work of this study was evaluating the performance of natural coagulant for removing pollutants which are pH, turbidity, and TSS from wastewater.

2. Materials and Methods

The natural coagulant that has been used for this study were moringa oleifera, citrullus lanatus seeds and hibiscus seeds. In this chapter, it explained about sample preparation for coagulant powder from different types of natural coagulant. Powder that extracts from different types of plant-based waste was used to analyze the effectiveness of natural coagulant in treating wastewater. This experiment was conducted by using a jar test. The results of treating leachate wastewater are being analyzed based on two parameter which are pH reduction and turbidity removal.

2.1 Powder Preparation

The powder preparation process involves washing moringa oleifera, citrullus lanatus and hibiscus seeds with distilled water to remove dirt and contaminants. The plants are dried in an oven at 105°C for 7 hours. The dried plants are ground into a powder using a domestic blender, ensuring a 425μm sieve size. The extract powder is filtered and labeled as Moringa Oleifera Coagulant (MOC), Citrullus Lanatus Coagulant (CLC), and Hibiscus Seeds Coagulant (HSC).

2.2 Jar Test

The wastewater sample was prepared by taking the bottle from the cold room and shaking it to ensure that there are no suspended particles at the bottom of the bottle and to ensure the wastewater sample even. The initial temperature and turbidity of the wastewater sample was measured. The preparation of wastewater sample was placed from (1) into (6) different beakers (plexiglass graduated beakers) with 250 mL each. After that, preparation of natural coagulant sample for MOC, CLC and HSC with the different ratio of natural coagulant and alum (1:1). Then, the sample will undergo constant rotation in jar test of 140 rpm for the first 3 minutes then the stirring continued at 10-40 rpm for 1 hour. Next preparation of MOC, CLC and HSC sample with the different ratio of natural coagulant and alum (1: 1-1:3). Then, the sample will undergo constant rotation in a jar test of 140 rpm for the first 3 minutes then the stirring continued at 20 rpm for 1 hour.

2.3 Analysis of Result

Three different sample of natural coagulant was extracted to measure the turbidity of wastewater and pH to analyze the effectiveness of MOC, CLC and HSC in treating wastewater based on different ratio of natural coagulant with alum and speed of rotation of jar test. The turbidity of water is measured to determine the cloudiness of each sample solution after using MOC, CLC and HSC. It is a quantitative characteristic which is imparted by solid particles obstruction the transmittance of light through a water sample. The turbidity value is measured by a turbidity meter with a nephelometric turbidity unit (NTU). The term pH refers to the measure of hydrogen ion concentration in a solution by using pH meter.

3. Results and Discussion

Table 1 *The initial value pH, turbidity and temperature of wastewater sample*

Parameter	Value
pH	8.82
Turbidity, NTU	66.1
Temperature, °C	23.3

Based on the Table 1, it shows the initial value of the wastewater sample. The value for wastewater sample for pH, turbidity and temperature are 8.82, 66.1 NTU and 23.3.

3.1 Speed of Rotation

Table 2 *Results speed of rotation for turbidity removal and pH*

Natural coagulant	Speed of rpm	pH reduction	pH reduction (%)	Turbidity removal (NTU)	Turbidity removal (%)
MOC	10	8.13	7.8	54.4	17.7
	20	8.40	4.76	61.3	24.2
	30	8.27	6.24	63.1	-4.84
	40	8.44	4.31	77.6	-17.39
HSC	10	8.26	6.35	50.1	7.3
	20	8.29	6.00	49.6	25
	30	8.18	7.26	84.7	-24.36
	40	8.03	8.96	75.7	-14.52
CLC	10	8.34	5.44	69.3	-17.4
	20	8.27	6.24	77.6	-14.5
	30	8.32	5.67	82.2	-40.5
	40	8.48	3.85	92.2	-39.49

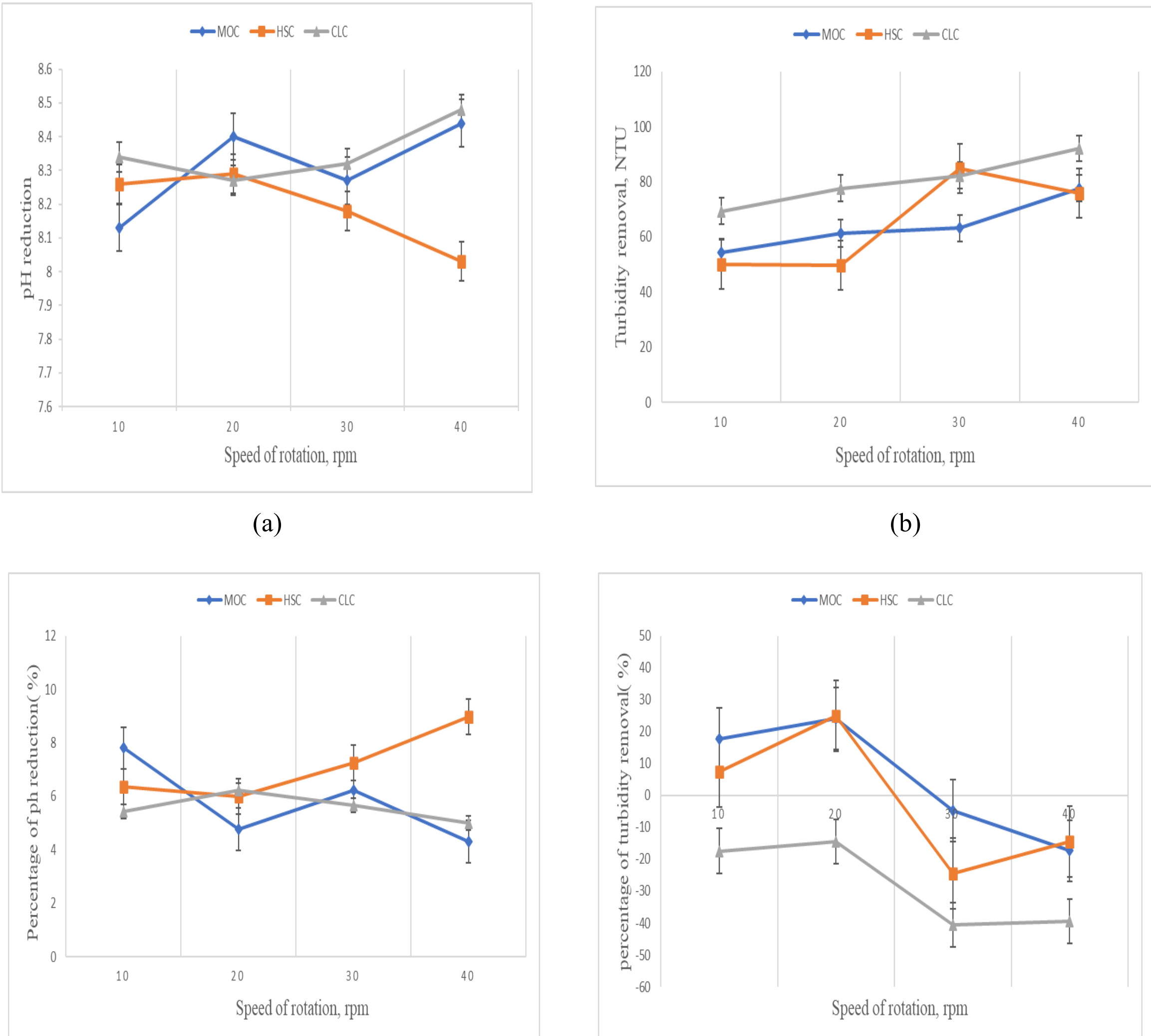
Table 2 shows the result obtained for the speed of rotation for the turbidity removal and pH reduction. This experiment was carried out using a standard jar test apparatus. In this experiment, a dosage of 0.1 mg/L of coagulants was added to the water sample of leachate for each beaker with initial turbidity of 66.1 NTU. The data trend shows that the turbidity removal decreases with increasing the speed of rotation of a jar test. As seen in the Table 2, the best result was obtained for the 10 rpm of speed of rotation compared to 20 rpm, 30 rpm, and 40 rpm. The turbidity removal for 10 rpm of MOC, HSC and CLC was observed to decrease from 66.1 NTU to 54.4 NTU, 50.1 NTU and 69.3 NTU. For 20 rpm, the reduction of turbidity for MOP, HSP and CLC is 61.3 NTU, 49.6 NTU and 77.6 NTU.

Next, for 30 rpm the turbidity removal for MOP, HSP and CLC is 63.1 NTU, 84.7 NTU, and 82.2 NTU. Lastly for 40 rpm, the turbidity removal for MOC, HSC and CLC is 77.6 NTU, 75.7 NTU and 92.2 NTU. The percentage of highest efficiency for 10 rpm for Moringa Oleifera Powder (MOP), Hibiscus Seed Powder (HSP) and Watermelon Seed Powder (WSP) was attained at 17.7%, 24.2% and -4.84% respectively. For 20 rpm, the turbidity removal of MOC, HSC and CLC decreases to 7.3%, 25%, and -17.40%. For 30 rpm, the turbidity removal of MOC, HSC and CLC decreases to 4.5%, -28%, and -24.36%. For 40 rpm, the turbidity removal of MOC, HSC and CLC decrease rapidly to -17.4%, -14.5%, and -40.5%.

From the percentage of turbidity removal, it was found out that the mixing speed affected floc size and strength more than the time. Because additional mixing time may increase the likelihood of particle and flocculant colliding, the slow speed mixing rate has a higher efficiency [3]. The results obtained approved that the better results for this suspension with a rapid mixing of a speed 10 rpm and the best coagulants used is HSC. The HSC provide excellent efficiency in coagulation process compared to MOC and CLC.

However, there might be some error during conduct this experiment because the percentage of turbidity removal does not show any changes, but the value of percentage has given negative value which increase the turbidity. After doing some observation, the error occur might because of amount of water sample of leachate used is too small which is only 250mL with amount of coagulant dosage 0.1 g. When the used of high dosage with less amount water sample, it will lead to overdosing which can be a serious mistake in that because it may create established suspension that is extremely difficult to separate and coagulate. The stream's suspended solids may become unstable because of an overdose of coagulant, affecting the entire treatment procedure. To avoid overdosing or underdosing for a better water treatment procedure, it is crucial to control the dosage of natural coagulant used with an appropriate amount of water sample [4].

The results of the pH effect on the turbidity removal are depicted in Fig.1. This figure clearly shows that the removal of turbidity was considerably influenced by the water pH; as the water pH decreases after added coagulants, the efficiency of the turbidity for all the mixing speed decrease respectively. This phenomenon can be explained by the fact that the pH influences the surface charge of the MOC, HSC and CLC particles in the solution. Based on the figure, mixing speed of 10 RPM shows the decreases value of pH too small compared to 20 RPM, 30 RPM, and 40 RPM. From the figure, it was out that the higher the speed of rotation, the smaller the changes in pH value. However, HSP has the highest change in pH. The turbidity removal for water pH 8.13 was 98.9%, a little less than turbidity removal efficiency that was attained at water pH 8.26, 99.6%. Since surface water resources are normally neutral, it is preferable to achieve maximal coagulation effectiveness at close to neutral pH since the pH of water does not need to be altered for effective coagulation [4].



(d)

Fig. 1 *(a) Graph speed of rotation (rpm) vs pH reduction (b) Graph speed of rotation (rpm) vs turbidity reduction (NTU), (c) speed of rotation vs pH reduction percentage (%) (d) speed of rotation (rpm) vs turbidity reduction percentage (%)*

3.2 Ratio of Alum

Table 3 *Results pH reduction and turbidity removal for ratio of alum*

Natural coagulant	Coagulant dosage	pH reduction	pH reduction (%)	Turbidity removal (NTU)	Turbidity removal (%)
HSC	0.1	8.22	6.8	54.4	17.5
	0.2	8.29	6.0	58.4	13.7
	0.3	8.15	7.6	58.6	10.6
MOC	0.1	8.47	4.0	54.4	17.7
	0.2	8.50	3.6	57.0	11.7
	0.3	8.57	2.9	59.1	11.4
CLC	0.1	8.21	7.0	64.4	2.6
	0.2	8.38	5.0	89.1	-34.8
	0.3	8.25	6.5	117	-77.0

Table 3 shows the result obtained for dosage for the turbidity removal and pH reduction. Based on the data in Table 3 above, the pH reduction for HSC at 0.1g, 0.2g, and 0.3g coagulant dosages was 8.22, 8.29, and 8.15, respectively, while MOC was 8.47, 8.50, and 8.57, and CLC was 8.21, 8.38, and 8.25. The next result for turbidity removal achieved for HSC at 0.1g, 0.2g, and 0.3g coagulant dosages was 54.4, 58.4, and 58.6, respectively, while MOC was 54.4, 57.0, and 59.1, and CLC was 64.4, 89.1, and 117. Apart from that, the pH reduction percentage obtained for HSC at 0.1g, 0.2g, and 0.3g amounts of coagulant dosage was 6.8%, 6.0%, and 7.6%, respectively, while MOC was 4.0%, 3.6%, and 2.9%, and CLC was 7.0%, 5.0%, and 6.5%. Lastly, the turbidity reduction percentage obtained for HSC at 0.1g, 0.2g, and 0.3g amounts of coagulant dose was 17.5%, 13.7%, and 10.6%, respectively, while MOC was 17.7%, 11.7%, and 11.4%, and CLC was 2.6%, -34.8%, and -77.0%.

The hibiscus seed coagulant (HSC) was found to be the most successful for pH and turbidity reduction percentage in wastewater treated with three natural coagulants which are Moringa oleifera, hibiscus, and Citrullus Lanatus. The HSC showed a significant drop in turbidity reduction percentage of 13.9% and pH reduction percentage of 6.8%. Compared to Moringa oleifera and Citrullus Lanatus coagulants, HSC showed lower average percentage decreases in pH and turbidity reduction percentages. Furthermore, increasing the natural coagulant dose led to a decrease in turbidity and pH reduction percentages. Figure 3.2 shows that hibiscus coagulant treatment resulted in 17.5%, 13.7%, and 10.6% turbidity reduction percentages at 0.1g, 0.2g, and 0.3g dosages, while pH reduction percentages were 6.8%, 6.0%, and 7.6%.

High turbidity wastewater requires a lower coagulant dose due to the frequency of particle and coagulant collisions [5]. Freezing is more likely due to a high concentration of pollutants and collisions, requiring a reduced coagulant dosage [6]. Low turbidity requires a higher coagulant dose due to the decreased frequency of foreign matter contact. Overdosing can cause charge reversal and particle repulsion, preventing floc formation. Overdosing reduces the number of accessible adsorption sites, making it impossible to add extra coagulant to the wastewater treatment process [7]. A smaller dose leads to partial and inefficient coagulation, as most particles remain suspended.

Table 3 shows that higher pH values result in higher turbidity reduction due to sedimentation due to the opposing charge of a colloid ion. An error occurred during the experiment, causing the turbidity value to be excessively high due to the small wastewater sample used. When a 0.1g coagulant dosage is used, the results for turbidity reduction are good, but when the dosage is increased to 0.2g and 0.3g, the results are worse. This is because small wastewater samples affect coagulation and flocculation processes and detect suspended solid elements [4].

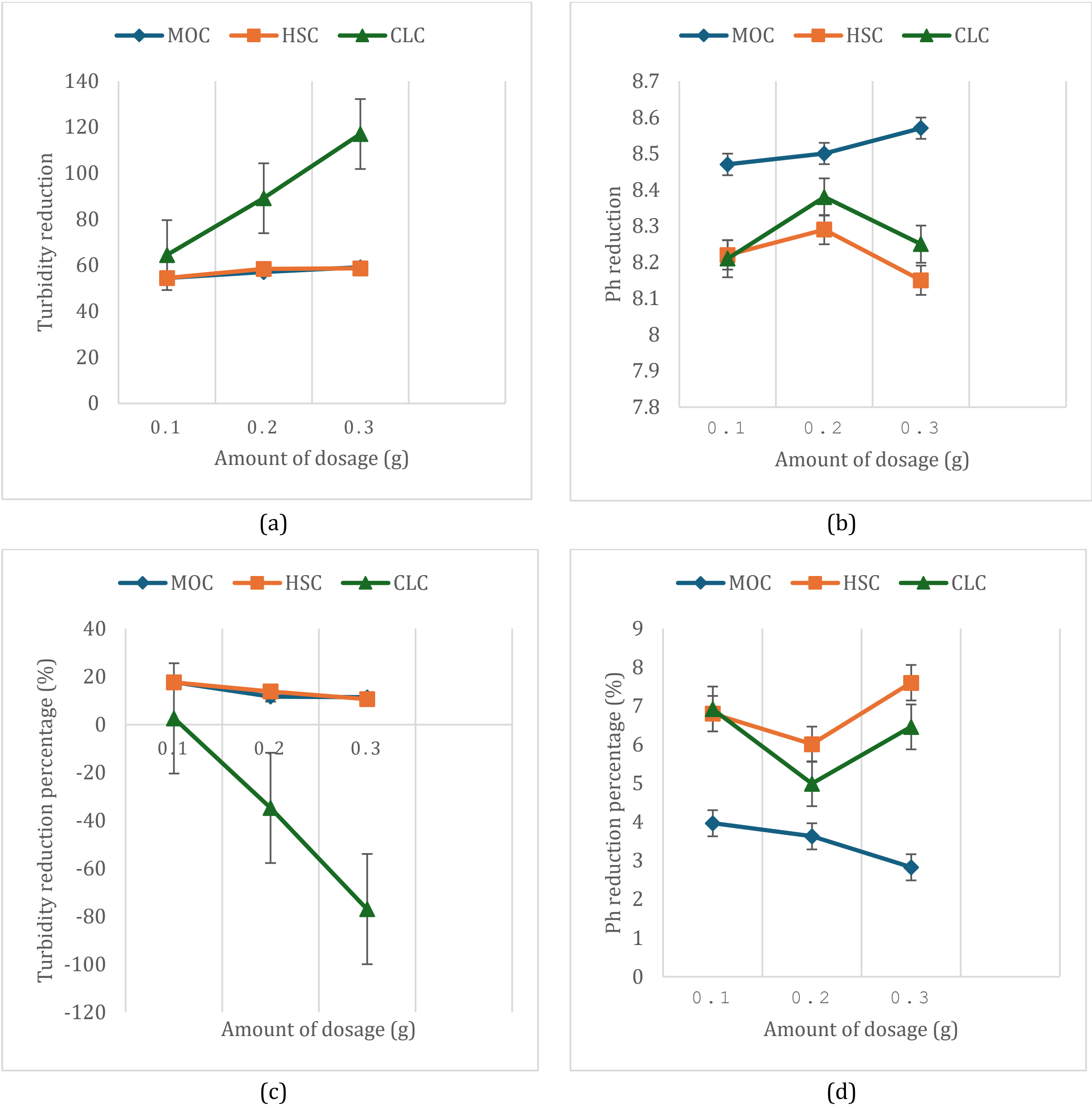


Fig.2 *(a) Graph amount of dosage (g) vs turbidity reduction (NTU), (b) Graph amount of dosage (g) vs pH reduction, (c) Graph amount of dosage (g) vs turbidity reduction percentage (%) (d) Graph amount of dosage (g) vs pH reduction percentage (%)*

4. Conclusion

Natural coagulants are generally regarded as nontoxic and safe due to their natural origin. MOC, HSC and CLC have shown bio coagulation activity, which is an exploitable property, since the quality parameters of water sample treated proved the efficiency of natural coagulants. The results of the effects on the turbidity and pH also indicate that the bio coagulant has the potential to be used as a biodegradable active ingredient in water disinfection. The results show the effectiveness of HSC is the most efficient in turbidity removal and pH balance compared to MOC and CLC. Results demonstrated that the higher the speed of rotation, the effectiveness of coagulant decreases and the lower amount of natural coagulant dosage used the higher the percentage turbidity and pH reduction.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nur Aisyaa Ayop, Nurul Aina Najwa Ruslan, Nur Shahirah Mohd Aripen;* ***data collection:*** *Nur Aisyaa Ayop, Nurul Aina Najwa Ruslan, Nur Shahirah Mohd Aripen;* ***analysis and interpretation of results:*** *Nur Aisyaa Ayop, Nurul Aina Najwa Ruslan, Nur Shahirah Mohd Aripen;* ***draft manuscript preparation:*** *Nur Aisyaa Ayop, Nurul Aina Najwa Ruslan, Nur Shahirah Mohd Aripen. All authors reviewed the results and approved the final version of the manuscript.*

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