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Differences in the Effectiveness of Moringa Seed Powder (*Moringa oleifera*) and Tamarind *(Tamarindus indica)* in Reducing *Chemical Oxygen Demand (*COD) Levels

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ABSTRACT

Industrial tofu liquid waste is waste produced from the tofu production process, such as soy washing and boiling, which has the characteristics of brownish-yellow, pungent stench and contains high organic matter. Tofu industrial liquid waste contains *Chemical Oxygen Demand* (COD) levels. The purpose of the study was to analyze the difference between moringa seed powder, tamarind seed powder and the combination of the two on the decrease in *Chemical Oxygen Demand* (COD) levels in tofu industrial liquid waste. The type of laboratory experiment research with a Complete Random Design (RAL) research design uses moringa seed powder, tamarind and a combination of the two with a dose variation of 3 grams, 4 grams and 5 grams. The sample is 6 liters of tofu wastewater obtained using *the grab sample* technique. The test used was *Kruskal-Waliis* The initial COD level in this study was 1800 mg/L
The results of this study showed that the initial COD level in tofu liquid waste was 1800 mg/L. The effectiveness of coagulants in reducing COD levels was 5 grams of moringa powder, 5 grams of tamarind and a combination of 5 grams with a percentage reduction of 85%, 89% and 90% respectively. There was no difference in decrease in each dose used to lower COD levels (*p-value* = 0.368). It is recommended to test other variables such as sedimentation time, as well as stirring variations.

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BACKGROUND

Soybeans that are processed into tofu are familiar to the Indonesian people. Based on the Central Statistics Agency, around 38% of soybeans in Indonesia can be consumed in the form of tofu. Data obtained from the Central Bureau of Statistics and National Socio-Economic Survey, stated that Indonesians consume tofu reaching 18.6 kg/capita/year in urban areas and 13.9 kg/capita/tofu in rural areas.

Many middle-class Indonesian people open tofu factories on a home scale. Where there are, about 84,000 tofu industries (1). Based on data from the Ministry of Agriculture, soybean production in 2021 in Indonesia was 613.3 thousand tons, in 2022 it was 594.6 thousand tons, in 2023 soybean production will be 576.3 thousand tons and in 2024 it will be 558.3 thousand tons (2). The existence of the tofu industry affects the amount of tofu liquid waste produced.

Tofu liquid waste comes from the process of washing, boiling, milling and printing tofu. Tofu liquid waste contains high organic matter and the level of *Biological Oxygen Demand*, *Chemical Oxygen Demand*, which is quite high, if it is directly discharged into water bodies. This will reduce the carrying capacity of the environment and require liquid waste treatment so as not to pollute the environment.

Tofu liquid waste treatment includes filtration and sedimentation which is a physical method, chemical methods namely coagulation and flocculation and biology namely phytomediation, bioremediation with macroorganisms. In this study, the researcher used the coagulation-flocculation chemical method in the process of reducing the level *of Chemical Oxygen Demand* (COD) in tofu industrial liquid waste by using coagulant moringa seed powder and tamarind.

Moringa seeds are an alternative to tofu liquid waste treatment which is known to have a high protein content, which is around 147,280 ppm/gram in the cotyledon. The protein has a positive charge that is able to neutralize the negative charge of colloidal particles in the wastewater, thus causing deposition. Based on research (3) in one of the tofu factories, the use of moringa seed powder with a dose of 4 grams and a quick stirring of 100 rpm with a stirring time of 3 minutes, was able to reduce COD levels by 64.88%.

Sour seeds contain starch that functions as a flocculant. The starch content can help collect suspended particles in the waste, including high levels of COD. Based on research (4) it shows that the use of tamarind seeds at a dose of 4 g/L with pH 8 is able to reduce COD levels by 82%, with a reduction in stirring speed by 40 rpm for 12 minutes. Another study showed that a dose of 4.5 grams of tamarind seed powder was able to efficiently reduce COD levels by 83.36% (5). These results indicate that tamarind seeds are quite effective in reducing the burden of organic pollutants in tofu liquid waste, and can be used as a natural coagulant that is able to reduce polluted parameters in tofu liquid waste.

Based on the results of initial interviews at the Aina and Pii Tofu Factory, this factory started operating in 2019, and produces tofu as many as 3 colli or 25 kg/coli, which produces 45-48 boards of tofu for one production per day. The water used in the production process is dug wells and is flowed using electricity to the water reservoir. Tofu liquid waste is produced from the production process, namely soybean soaking which will produce dissolved protein, soybean washing and milling, soybean juice filtering, tofu squeezing and washing of tools and whey residue (tofu water). This can cause high levels of COD in the tofu industrial liquid waste in the Aina and Pii tofu factories.

Based on research (6) in the ABC tofu factory using 75 kg of soybeans, the clean water needed for the production process is 4350 liters, while the total tofu liquid waste produced is 3813.3 liters. The results of the calculation are based on the water balance approach. Based on the results of initial observations, the residual water from tofu processing is flowed from pipes to the ground, continuing to waterways and directly into rivers. This causes a strong odor around the factory area.

Based on the initial water sample testing carried out at the Gorontalo Provincial Health Laboratory, which refers to Annex XVIII of the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Wastewater Quality Standards for Soybean Processing Businesses and/or Activities. The parameter tested, namely COD, showed a fairly high result, namely with a result of 1,751 with a standard quality of 300 mg/L. Therefore, the purpose of this study is to analyze the difference between moringa seed powder, tamarind, and the combination of the two in reducing the level *of Chemical Oxygen Demand* (COD) in tofu liquid waste. The benefit of this research is that it can be used as a reference in the field of research in reducing COD levels in tofu industrial liquid waste, using natural coagulants.

RESEARCH METHODS

The method used in this study is a laboratory experiment using a Complete Random Design (RAL). Complete Random Design (RAL) is complete randomization or infinite randomization in a relatively homogeneous laboratory experiment. In this study, 3 treatments and 1 control were used, where treatment 1 was tofu wastewater with the addition of moringa seed powder with a dose variation of 3 grams, 4 grams, 5 grams. Treatment 2 is tofu wastewater with the addition of tamarind seed powder with dosage variations of 3 grams, 4 grams, 5 grams. Treatment 3 is the addition of a combination of moringa seed powder and tamarind with a ratio of 1:1 at a dose variation of 3 grams, 4 grams and 5 grams. The population used is the wastewater of the Tahu Aina and Pii Factories located in South Ayula Village, Bone Bolango District, Bone Bolango Regency. The sample of this study is wastewater as much as 6000 ml/L, with sampling using *the Grab Sample* method which is based on SNI 6989:59:2008. Furthermore, the data was analyzed using statistical test data analysis techniques with computer software. The stages of statistical testing in this study are data normality tests, variance homogeneity tests, and one-way variance analysis tests using *One Way* ANOVA or using the Kruskal-Wallis test.

RESULTS

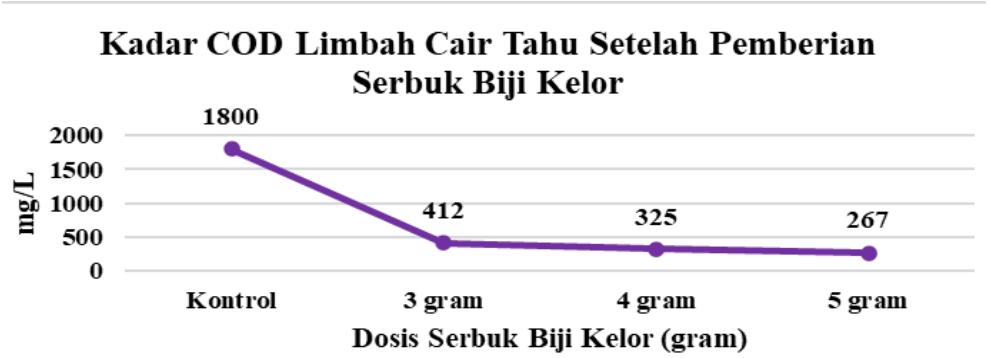
Differences in the Effectiveness of Moringa Seed Powder (*Moringa oleifera*) and Tamarind (*Tamarindus indica*) in Reducing *Chemical Oxygen Demand* (COD) Levels in Tofu Industrial Liquid Waste.

Table 1. COD Levels Results After Coagulant Moringa Seed Powder, Tamarind and a Combination of the Two.

Types and Dosages of Coagulants	COD level (mg/L)	Quality Standard (mg/L)	Categories
Controls	1800	300	TMS
Moringa Seed Powder 3 Grams	412	300	TMS
Moringa Seed Powder 4 Grams	325	300	TMS
Moringa Seed Powder 5 Grams	267	300	MS
Tamarind Seed Powder 3 Grams	360	300	TMS
Tamarind Seed Powder 4 Grams	291	300	MS
Tamarind Seed Powder 5 Grams	200	300	MS
Powder Combination of the two 1:1 3 Grams	300	300	MS

Types and Dosages of Coagulants	COD level (mg/L)	Quality Standard (mg/L)	Categories
Powder Combination of the two 1:1 4 Grams	210	300	MS
Powder Combination of the two 1:1 5 Grams	188	300	MS

Source : Primary Data, 2025
Description :
MS : Qualified
TMS : Not Eligible



Source : Primary Data, 2025
Figure 1. COD Levels of Tofu Liquid Waste After Moringa Seed Powder Injection

Based on Figure 1, it is known that the value of *the Chemical Oxygen Demand* (COD) level in tofu liquid waste before the treatment of giving moringa seed powder is 1800 mg/L, and after the administration of moringa seed powder, the COD level decreases at a dose of 3 grams of 412 mg/L, then the dose is increased to 4 grams, the COD level drops by 325 mg/L, and increase it again to 5 grams, COD levels in liquid waste show a significant decrease of 267 mg/L

Source : Primary Data, 2025
Figure 2. COD Levels of Tofu Liquid Waste After Giving Tamarind Seed Powder

Based on Figure 2, it is known that the value of *the Chemical Oxygen Demand* (COD) level in tofu liquid waste before the treatment of giving tamarind seed powder is 1800 mg/L, and after the administration of tamarind seed powder, the COD level decreases at a dose of 3 grams of 360 mg/L, then the dose is increased to 4 grams, the COD level drops by 291 mg/L, and increase it again to 5 grams, COD levels in liquid waste show a significant decrease of 200 mg/L.

Source : Primary Data, 2025

Figure 3. COD Levels of Tofu Liquid Waste After Applying Moringa Seed Powder and Tamarind

Based on Figure 3, it is known that the value of *the Chemical Oxygen Demand* (COD) level in tofu liquid waste before the treatment of giving a combination of moringa seed powder and tamarind is 1800 mg/L, and after the combination of tamarind seed powder is given, the COD level decreases at a dose of 3 grams of 300 mg/L, then the dose is increased to 4 grams, COD levels decreased by 210 mg/L, and increased again to 5 grams, COD levels in liquid waste showed a decrease of 188 mg/L.

Based on the *Shapiro-Wilk* test that was carried out previously, the data was not distributed normally, then continued with the *Kruskal-Waliis test,* the following table 2 of *the Kruskal-Wallis test:*

Table *2. Kruskal Wallis Test*

Coagulant Type	Dosage (g)	*p-value*
Moringa Seed Powder, Tamarind and a Combination of Both	3 Grams	0.368
	4 grams	
	5 grams	

Based on Table 2. In moringa seed powder, tamarind and a combination of both contain the same result, namely a *p-value* of 0.368> 0.05, which means that there is no difference in each coagulant treatment, both moringa seed powder, tamarind and a combination of the two with a dose variation of 3 grams, 4 grams and 5 grams.

DISCUSSION

Differences in COD Levels in Tofu Industrial Liquid Waste When Given Moringa Seed Powder with Dose Variations of 3 grams, 4 grams, 5 grams.

The measurement of *the Chemical Oxygen Demand* (COD) level before the administration of moringa seed dose in tofu industrial wastewater samples was 1800 mg/L. At a dose of 3 grams, the COD level after the administration of moringa seed powder was 421 mg/L, with a percentage reduction of 77%. When the dose was increased to 4 grams, the COD level dropped to 325 mg/L, with an efficiency of 82%, at the 5-gram dose it reached 267 mg/L, accompanied by an increase in the efficiency of the decrease to 85%, which is the highest efficiency of this treatment. The results obtained at a dose of 5 grams meet the quality standards of the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Wastewater Quality Standards for Soybean Processing Businesses and/or Activities, namely with a quality standard of 300mg/L.

The decrease in COD levels can be influenced by pH stability, as well as dosage ability, the higher the dose used, the higher the decrease in COD levels, at a dose of 5 grams is able to meet the quality standards of the Minister of Environment Regulation Number 5 of 2014, and can be an environmentally friendly alternative. Moringa seed powder can be used as a natural coagulant in reducing COD levels in tofu liquid waste. The selection of moringa seeds as kaogulan is based on its characteristics, namely using mature and dried seeds. Based on research (Lafiyah, 2018), moringa seeds have a relatively high protein content, which is around 147,280 ppm/gram in the cotyledon.

Based on Syukma's research (7), a dose of 4 grams of moringa seed powder was able to reduce the COD level of tofu liquid waste with a percentage reduction of 75% with a stirring speed of 100 rpm for 3 minutes, followed by slow stirring at 40 rpm for 15 minutes, and sedimentation for 24 hours. In study (8), the stirring

speed of 100 rpm was proven to be able to reduce COD levels in tofu liquid waste by 80%, with a sedimentation time of 60 minutes, and a slow stirring of 40 rpm for 12 minutes.

Differences in COD Levels in Tofu Industrial Liquid Waste When Given Tamarind Seed Powder with Dosage Variations of 3 grams, 4 grams, 5 grams

The results of measuring *the Chemical Oxygen Demand* (COD) level of tofu industrial liquid waste before being treated with the addition of tamarind seed powder were at 1800 mg/L, which means that the COD level in tofu industrial liquid waste has a high organic content content. After the addition of tamarind seed powder in a dose variation of 3 grams, there was a significant decrease in COD levels of 360 mg/L with a percentage reduction of 80%, then the dose was increased to 4 grams and there was a decrease in COD of 291 mg/L with a percentage of 84% and at a dose of 5 grams showed a reduction in COD of 200 mg/L with a percentage reduction of 89%. Based on the quality standards of the Regulation of the Minister of Environment Number 5 of 2014, the doses of 4 grams and 5 grams have met the requirements and experienced a significant decrease in COD levels.

Based on the standard of the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 of 300 mg/L, the 3-gram dose has not met the standard even though it has provided a significant reduction. The dosage of 4 grams and 5 grams has met the quality standards. The success of a 5-gram dose is not only affected by the increase in coagulants but also affected by the time of floc formation. This is in line with the research conducted by , where at a dose of 4.5 grams with a slow stirring time of 40 rpm for 10 minutes was able to produce a percentage reduction of 83%. (Suryo et al., 2020)

Another study (9) showed a 50% decrease with a stirring time of 4 minutes. The difference in efficiency with this study is due to the stirring time, in this study using slow stirring for 12 minutes, so that the floc formed is more stable and easy to settle. The research conducted by (10) also supports this finding, where a dose of 4 grams reduces COD levels by 82% through the bonding of positively charged starch compounds and negatively charged organic particles, causing large flocs and easy sedimentation. Overall, increasing the dosage has been shown to improve the oogulation of organic matter to some extent.

Differences in COD Levels When Given a Combination of Moringa Seed Powder and Tamarind Seed Powder with Dosage Variations of 3 grams, 4 grams, 5 grams.

The results of the study show that the combination of moringa seed powder and tamarind seeds has an effective ability to reduce the level *of Chemical Oxygen Demand* (COD) in tofu industrial liquid waste. Based on the study, COD levels before treatment had a value of 1800 mg/L, and after treatment at a dose of 3 grams of 300 mg/L, at a dose of 4 grams became 210 mg/L, at a dose of 5 grams became 188 mg/L. The percentage of decrease in COD levels was 83%, 88% and 90%, respectively. From the three results obtained, all dose variations met the quality standards of the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Wastewater Quality Standards for Soybean Processing Businesses and/or Activities, namely with a quality standard of 300 mg/L.

The combination of these materials allows for more optimal electrostatistical interactions between suspended particles and organic compounds in waste. Meanwhile, tamarind powder, which is rich in polysaccharides, tannins, and phenolic compounds, will act as *bridging* and adsorbent agents, where these components form a physical bridge between solids that have been neutralized by moringa powder and increase floc binding through hydrogen, hydrophobic, and non-covalent complexes of dissolved organic molecules. This process does not produce a new covalent chemical reaction between the two powders, but the physiciconian interactions that form result in larger, more stable flocs, and higher adsorption capacities. Therefore, the combination of moringa seed powder and tamarind powder is able to improve the separation of organic particles and reduce the COD load more effectively than using either ingredient alone. (Fitria et al., 2024)

CONCLUSION

Based on the results of the study on moringa seed powder with a dose variation of 3 grams, 4 grams, 5 grams, it showed the results of a consecutive reduction in COD levels of 412 mg/L, 325 mg/L, 267 mg/L with the initial COD level of tofu industrial liquid waste of 1800 mg/L. The effectiveness of each coagulant was 3 grams, 4 grams, 5 grams respectively, which was 77%, 82%, 85%. In tamarind seed powder, the results of reducing COD were successively reduced by 360 mg/L, 291 mg/L, 200 mg/L with the initial COD level of tofu industrial liquid waste of 1800 mg/L. The effectiveness of each coagulant was 3 grams, 4 grams, 5 grams respectively, namely 80%, 84%, 89%. In the combination of the two powders with a ratio of 1:1 at doses of 3 grams, 4 grams and 5 grams respectively of 300 mg/L, 210 mg/L, 188 mg/L with the initial COD level of tofu industrial liquid waste of 1800 mg/L. The effectiveness of each coagulant is 3 grams, 4 grams, 5 grams, which is 83%, 88%, 89%. Statistically, the *Kruskal Wallis* test on moringa seed powder, tamarind and combination got a *p-value of* 0.368 >0.05, which means that each treatment showed the same value and/or had no difference in each coagulant and the dose given.

ADVICE

Suggestions for further research are expected to be able to expand the study of the use of other natural ingredients as coagulants or bioflocculants, for industry owners it is recommended to consider the use of moringa seed powder and tamarind as an alternative in reducing COD levels in wastewater, for academics it is expected to conduct further research, namely by testing other variables, such as settling variations, stirring variations, and modification of moringa and tamarind dosages 1:2, so that it can result in a more optimal reduction in COD levels.

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