UTILIZATION OF WATER HYACINTH FROM EUTROPHICATED WATER OF EMBUNG GRABAG PURWOREJO FOR PRODUCTION OF POWDERED HUMIC ACID

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Abstract. One solution to overcome the problem of water eutrophication is to utilize water hyacinth for humic acid production. In this process, additional materials are needed as a carbon source and a microorganism activator. The objectives of this study were (1) to determine the interaction between plant parts and molasses to produce the highest humic acid. This study used a Completely Randomized Design (CRD) with two factors: plant parts (roots, stems, leaves) and concentration of molasses (50, 100, 150, 200 $mLkg^{-1}$) for 3 times replication. The parameter measured was the production of dry weight of humic acid powder. Data analysis used ANOVA and continued with the DMRT test. The results showed that there was a significant effect of molasses concentration on the fermentation of the different plant parts. This study can be concluded that different concentrations of molasses and plant parts showed differences in the resulting humic acid production. The conclusion showed that the addition of 150 $ml.kg^{-1}$ molasses to the fermentation of water hyacinth roots (AM3 treatment) produced the highest humic acid content up to 98.5 $g.kg^{-1}$ or 9.5%.

Keywords: Eutrophication, Fermentation, Humic Acid, Molasses, Water Hyacinth

1. Introduction

Eutrophication occurs when nutrients such as nitrogen and phosphate are excessive in water, which can damage aquatic ecosystems [3]. One indicator of eutrophication is the uncontrolled growth of aquatic plants such as water hyacinth. Water hyacinth is known as a weed due to its rapid growth, covering the water surface. In addition to environmental problems, water hyacinth also has benefits, especially in terms of biomass. This plant can be used as organic fertilizer through composting, producing humic acid, which is beneficial for improving soil fertility. Humic acid is a complex organic compound formed from the decomposition of organic matter, including plant residues. This decomposition process requires a carbon source and microorganism activators such as EM4 to accelerate the development of microorganisms that assist in decomposition [1].

The parts of the water hyacinth plant, such as roots, stems, and leaves, produce different amounts of humic acid due to their chemical composition and structure. Each plant part has a specific function requiring certain chemical and structural adaptations [2]. Therefore, it is necessary to study the interaction between plant parts and the amount of carbon source in producing humic acid, so that water hyacinth, considered waste, can be converted into a high-value product for the agricultural sector.

The objectives of this research were: 1) to examine the interaction between water hyacinth plant parts and molasses concentration in producing humic acid, and 2) to determine the water hyacinth plant part and molasses concentration that produces the highest humic acid. The benefits of this research are expected to contribute to the sustainable management of water hyacinth waste, reduce eutrophication problems, and produce powdered humic acid products that are beneficial for the agricultural sector.

2. Methods

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3. Results And Discussion

The results showed that the interaction between plant parts and molasses addition at various concentrations during the composting process influenced the humic acid content produced (Table 1).

Table 1. ANOVA Results of Humic Acid Content

Parameter	(SV)	DF	SS	MS	F Cal	F Tab (0,05)
Humic Acid	Plant Part (PP)	2	519.370	259.685	39.162**	3.402
	Molasses Conc. (MC)	3	119.217	39.739	5.992**	3.008
	Interaction PP><MC	6	129.297	21.549	3.249*	2.508

Note : * = Significant at the 5% test level, ** = Significant at the 1% test level, SV= Source of Variation, DF = Degrees of Freedom, SS = Sum of Squares, MS = Mean Square

Based on the ANOVA results in Table 1, there is an interaction between the plant parts and molasses concentration that affects humic acid production. This shows that decomposition of different plant parts results in varying humic acid content due to the chemical composition of each plant part [4]. Humic acid, one of the products of organic matter decomposition, such as leaves, stems, and roots, has a chemical composition that influences its rate of decomposition. Each plant part has a different chemical composition. Leaves tend to have a higher nitrogen content compared to stems, which contain more lignin and cellulose [5]. Lignin is a complex compound that takes longer to decompose, which can affect humic acid formation [6]. Parts of the plant, such as the root, contain more lignin and cellulose than leaves and stems. Lignin is more difficult for microbes to decompose, resulting in differences in the humic acid produced between leaves and stems [7].

Water hyacinth is composed of cellulose, hemicellulose, and lignin, with different compositions in each part of the plant. Chemical analysis shows that water hyacinth is relatively rich in cellulose but poor in lignin compared to terrestrial biomass. Quantitatively, the cellulose and lignin content in the leaves is about 29.9% and 5.5%, in the stems (petioles) 29.3% and 18.4%, and in the roots 18.1% and 15.7% [8]. This data shows that leaves have a relatively high cellulose content but very low lignin, while the petioles contain the highest lignin content, and the roots have relatively lower cellulose but a sufficient amount of lignin. This finding is consistent with other reports, which state that the lignin content of water hyacinth is only about 6-14%, lower than that of woody biomass [9]. Meanwhile, the total cellulose or holocellulose content of water hyacinth is recorded at about 40-50% of dry weight [10], making it a carbohydrate-rich substrate. The low lignin and high cellulose content are key factors supporting the utilization of water hyacinth in humic acid conversion processes.

The roots of water hyacinth contain 8.8 - 13.4% lignin and around 27 - 28% cellulose [9]. Lignin makes the roots more potent than leaves or stems because it produces more stable aromatic compounds that serve as the backbone of humic acid, while cellulose is easier to break down as it provides energy for microorganisms and accelerates decomposition [11]. Molasses plays a role in providing simple energy, so microbes become more active in decomposing lignocellulose [12].

Table 2. Percentage of Humic Acid Content

No	Treatment	Humic Acid Production	
		(g/kg)	(%)
1	AM1 (root, molasses 50 mL.kg^{-1})	42.50^{bc}	4.25^{bc}
2	AM2 (root, molasses 100 mL.kg^{-1})	62.00^{b}	6.20^{b}
3	AM3 (root, molasses 150 mL.kg^{-1})	98.50^{a}	9.53^{a}
4	AM4 (root, molasses 200 mL.kg^{-1})	88.50^{a}	8.58^{a}
5	BM1 (stem, molasses 50 mL.kg^{-1})	21.00^{c}	2.10^{c}
6	BM2 (stem, molasses 100 mL.kg^{-1})	29.00^{c}	2.90^{c}
7	BM3 (stem, molasses 150 mL.kg^{-1})	41,85^{bc}	4.16^{bc}
8	BM4 (stem, molasses 200 mL.kg^{-1})	23.00^{c}	2.30^{c}
9	DM1 (leaf, molasses 50 mL.kg^{-1})	31,75^{c}	3.18^{c}
10	DM2 (leaf, molasses 100 mL.kg^{-1})	32,50^{c}	3.25^{c}
11	DM3 (leaf, molasses 150 mL.kg^{-1})	29,50^{c}	2.95^{c}
12	DM4 (leaf, molasses 200 mL.kg^{-1})	43.00^{bc}	4.30^{bc}

Note: The same letters following the numbers indicate no significant difference (5% DMRT test).

The results of the DMRT test showed that the combination of the root part of the plant with the addition of 150 mL.kg^{-1} molasses produced the highest humic acid content of 98.5 g.kg^{-1}or 9.5%. This is because roots generally contain higher amounts of lignin and cellulose compared to stems and leaves, thus providing precursors that better support the formation of humic acid [9]. In addition, the optimal dosage of molasses enhances the activity of decomposer microbes in degrading lignocellulose, making the process more efficient and resulting in a more optimal humic fraction [12].

Treatment AM3 was not significantly different from AM4, which produced 88.5 $g.kg^{-1}$ or 8.583% of humic acid. Therefore, the most efficient interaction was AM3 because it used less molasses but produced the highest amount of humic acid. Compared to leaves and stems, roots yielded higher amounts of humic acid due to their chemical properties. Leaves are indeed rich in nitrogen, but their high ash content reduces the organic fraction that can undergo humification [13]. Stems, on the other hand, have rigid cell walls with relatively low lignin content, making them more difficult to decompose by microorganisms [14].

The highest yield was found in treatment AM3, since using a smaller amount of molasses was already sufficient to produce maximum humic acid content. The highest results were obtained in the AM3 treatment, because the use of a smaller amount of molasses was sufficient to produce maximum humic acid levels. The availability of simple carbon in optimal amounts can increase the activity of decomposing microbes without causing the accumulation of intermediate compounds that can inhibit humification [15]. The humification process will be optimal if there is a balance between complex organic substrates and energy sources [16].

Excessive addition of molasses does not always increase humic acid yield because, at a certain point, microbial activity reaches its maximum capacity, and the excess carbon may cause an imbalance in the C/N ratio, which in turn slows down humic acid formation [17]. Molasses, which is rich in simple sugars such as sucrose and glucose, is easily used by microbes as an energy source, thereby accelerating the decomposition and degradation of organic matter [18]. The use of carbon additives such as molasses has also been proven effective in accelerating the humification process, i.e., the formation of humic compounds during composting [12]. This condition aligns with the principle of humic acid formation, which is optimal when there is a balance between the availability of complex organic substrates and fast energy sources, allowing microbes to effectively degrade the material [19]. Thus, the combination of raw material rich in lignin/cellulose and fast energy sources from molasses at optimal concentrations creates ideal conditions for microbial growth and accelerates lignocellulose degradation into humic compounds [20] [21].

The leaf part produced lower humic acid content compared to roots, with the highest yield of 43 g in treatment DM4 or 4.3%. The ash content in plants reduces the fraction of organic matter available for the formation of humic substances [22]. Leaves have a high ash content of about 13% of dry weight [23]. The main elements in water hyacinth ash are silica, calcium, and potassium [22]. In addition, the high water content of leaves and their thin tissue causes organic matter to degrade more quickly into simple compounds such as volatile organic acids [24]. These volatile organic acids mostly dissolve into solution, and only part of them are polymerized into humic acid [25]. The chemical composition of leaves generally has lower lignin and cellulose contents compared to roots and stems. Low lignin content means fewer aromatic precursors that can transform into quinones, which are the basic compounds in the humus formation pathway [26]. Meanwhile, the cellulose content of leaves is relatively adequate (around 20%), which is more easily decomposed or quickly fermented but does not enter into the polymerization process of humification [27].

The stem part showed the lowest humic acid yield in all treatments, with the highest value of 41.85 g in treatment BM3 and the lowest of 21 g in BM1. The chemical composition of water hyacinth stems has relatively low lignin content (4.5–5.9%) compared to roots and leaves [9]. This results in fewer aromatic precursors available for humification; thus, when lignocellulose is degraded, the amount of quinone to be polymerized into humic acid becomes more limited [28]. This proves that even with the addition of molasses, stems still produced less humic acid than roots (Table 2).

Overall, the humic acid powder from the decomposition of different plant parts showed variations in color, reflecting the diversity of chemical composition and structure of the original organic material [16] (Figure 1).

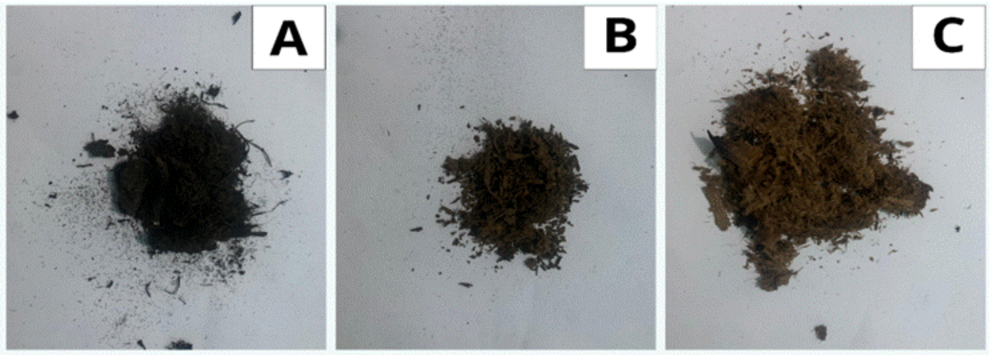

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Figure 1(A,B,C). Humic Acid Powder

The humic acid powder from the root part showed a dark blackish color (Figure 1A). This indicates a high level of humification with the dominance of stable compounds. The deep black color is generally associated with a high content of aromatic groups resulting from lignin degradation that successfully polymerized into humic fractions [29].

The humic acid powder from the leaf part appeared to have a darker brown color (Figure 1B), which indicates moderate humification. Some humic compounds had already formed, but there were still organic residues that had not been fully polymerized. Dark brown color indicates intermediate humification products [30].

The humic acid powder from the stem part appeared lighter brown in color (Figure 1C). Light brown color indicates a low content of humic substances and is still dominated by lignocellulosic residues that have not undergone humification, resulting in a smaller fraction of humic substances formed [31].

These findings reinforce the quantitative results that the root part with 150 mL/kg molasses is the most optimal combination in producing humic acid. Thus, this study not only investigates plant parts and molasses concentrations that yield the highest humic acid but also provides a practical basis for the utilization of *E. crassipes* as a raw material in eutrophication control strategies. Water hyacinth is known as an aquatic plant that absorbs excess nutrients (particularly nitrogen and phosphorus) from water during its growth, and therefore can also be used in the phytoremediation of eutrophic waters [32].

4. Conclusion

Based on the results of the study, it can be concluded that the interaction between the parts of the water hyacinth plant and molasses concentration had a significant effect on humic acid production. The most optimal treatment combination was the root part with the addition of 150 mL/kg molasses, as it produced the highest humic acid yield with more efficient use of molasses, namely 98.5 g/kg or 9.5%.

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