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Utilization of Dry Yeast with Distilled Water pH ≥ 8 as An Alternative Material for Concrete Crack Repair Based on Biomaterial

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ABSTRACT
This study was conducted to determine the ability of yeast with distilled water solvent at pH 8 to produce calcium carbonate deposits that are used to repair cracks in concrete. Distilled water was used instead of the expensive Tris Buffer solution. The research was conducted using a mixture of glucose, calcium carbonate, and various concentrations of yeast. The concentrations used were 13 g/L, 16 g/L, 19 g/L, 22 g/L, 25 g/L, 28 g/L, 31 g/L, 34 g/L, 37 g/L and 40 g /L, while for calcium acetate monohydrate used as much as 8.1 g, glucose 11.43 g for 32.5 ml of the mixture. The mixture was then deposited for 7 days at a temperature of 30°C so that perfect precipitation would occur. During precipitation, the pH was measured daily to determine the degree of decrease in pH. The greatest decrease in pH was observed in the yeast mixture at a concentration of 40 g/L and water pH of 9.09. From the results of precipitation for 7 days at a temperature of 30°C, it was found that the highest concentration of yeast was 34 g/L with a mixed molarity that could be used were 1.95 mol/L glucose, 1.41 mol/L calcium acetate monohydrate and 34 g/L of yeast.

Keywords: *Dry Yeast, Repairing Cracks, Concrete, Biomaterial*.

1. INTRODUCTION

Concrete has many advantages, including a relatively low price, durable material, high compressive strength, and relatively easy and common workmanship. In addition to its many advantages, concrete has several drawbacks that can be fatal to the structure, including that if it is not compacted properly, there will be separation of aggregates, hard concrete has a strength class, so it must be adjusted to the part of the building to be made, and concrete has tensile strength. The low one. Even though the construction process of making concrete has been performed as well as possible, small or large damages to concrete still occur. Concrete damage cannot be avoided by considering the long service life of the concrete. One of the common types of damage that occurs in concrete is cracking. According to [1] cracks are broken in concrete in the form of long narrow lines because of hot and windy weather. The damage is superficial and interconnected.

Several materials can be used to repair concrete cracks, including epoxy resins, cement grouting, and polyurethane. Most materials used for repairing concrete cracks are chemicals that can damage the environment. In addition, this conventional repair material has low viscosity; therefore, it is not optimal for repairing cracks in narrow concrete gaps.

In addition to chemical repairs, self-healing concrete repair methods have been developed. Self-healing is the ability of concrete to repair itself with the help of microorganisms mixed into fresh concrete or injected when the concrete is hard. Many concrete repair concepts have been developed, and one of the most interesting scientific approaches is curing using bio-based microorganisms or by adding biomaterials.

One technique that can be used to repair cracked concrete is microbial-induced calcium carbonate precipitation (MICP). MICP is a biological process by which active bacterial metabolism results in calcium carbonate deposition.

The biomaterial mixture was prepared using glucose, calcium acetate, and yeast as the main ingredients and then dissolved in a buffer solution of tris 2-amino-2 hydroxymethyl-1,3 propanediol/ $(HOCH_2)_3CNH_2$. However, the tris 2-Amino-2 hydroxymethyl-1,3 propanediol/ $(HOCH_2)_3CNH_2$ buffer solution is expensive, which increases the cost of making a mixture of biomaterials.

Distilled water was used to replace the tris 2-amino-2 hydroxymethyl-1,3 propanediol/ $(HOCH_2)3CNH_2$ buffer solution with pH ≥ 8. The tris 2-amino-2 hydroxymethyl-1,3propanediol/ $(HOCH_2)3CNH_2$ buffer solution was replaced with distilled water to reduce the cost of making yeast-based biomaterial mixtures. In addition, distilled water is easy to obtain.

To obtain the optimal amount of calcium carbonate precipitate in a mixture of yeast-based biomaterials and distilled water, a series of experiments is required. Therefore, the authors are interested in conducting research using distilled water with pH ≥ 8 as a solvent in a mixture of yeast-based biomaterials.

2. METHODOLOGY

The research was conducted at the Building Materials Laboratory, Civil Engineering Department, Faculty of Engineering, Universitas Negeri Padang. Data collection and experiments were carried out within one month in the laboratory.

The data needed were the primary data. Primary data are data provided or obtained directly by data collectors. In this research, the primary data needed are basic material specifications, specifications for distilled water as the solvent, and solution composition plan.

The total samples in this research are shown in Tables 1 and 2.

Table 1. Composition of Solution with Distilled Water pH ≥ 8

Number of Sample	Yeast Concentration (g/L)	Glucose (g/L)	Calcium Acetate Monohydrates	Total Sample
1	13	11,43	8,1	3
2	16	11,43	8,1	3
3	19	11,43	8,1	3
4	22	11,43	8,1	3
5	25	11,43	8,1	3
6	28	11,43	8,1	3
7	31	11,43	8,1	3
8	34	11,43	8,1	3
9	37	11,43	8,1	3
10	40	11,43	8,1	3

Table 2. Composition of Solution with Distilled Water pH ≥ 9

Number of Sample	Yeast Concentration (g/L)	Glucose (g/L)	Calcium Acetate Monohydrates	Total Sample
1	13	11,43	8,1	3
2	16	11,43	8,1	3
3	19	11,43	8,1	3
4	22	11,43	8,1	3
5	25	11,43	8,1	3
6	28	11,43	8,1	3
7	31	11,43	8,1	3
8	34	11,43	8,1	3
9	37	11,43	8,1	3
10	40	11,43	8,1	3

Tests were performed using the tube precipitation method to measure the pH of the mixture during and after the reaction. The main materials required are yeast, calcium acetate monohydrate, and $Ca(CH_3COO)_2.H_2O$, Glucose/$C_6H_{12}O_6$ and Distilled water with pH ≥ 8 and pH ≥ 9

The mixture in the beaker was subsequently stirred (500rpm in 5 minutes) or until each material was dissolved into the solution. And the Tris buffer solution was further added to make solution 160 mL totally. After separating samples to 4 test tube (each test tube was 40mL), the test tubes were placed in a temperature-controlled room for the measurement.

After several elapsed time, filtration was carried out to measure precipitation rate of calcium carbonate (weight method). On the other hand, the concentration of calcium ions and pH were measured in mixtures using commercially available meters (pH meter and calcium ion meter). Each test was carried out using two test tubes to confirm the consistency of results obtained.

The mixing process of bio-materials mixtures shown in Figure 1.

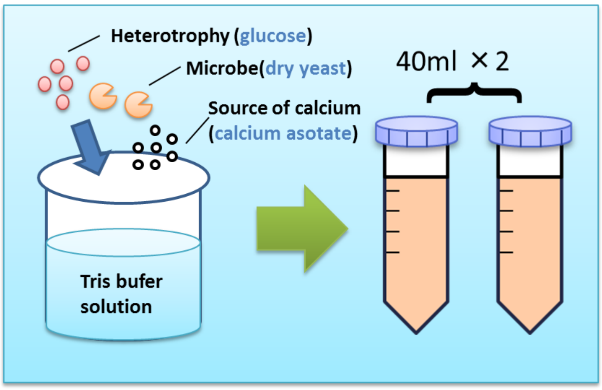

Figure 1 Mixing process of bio-materials mixture

The amount of Calcium Carbonate ($CaCO_3$) precipitation can be calculated by measuring the value of calcium ions using the following formula:

$$\text{Decreasing rate of calcium ions} = \frac{[C_o]-[C_a]}{[C_o]} \quad (1)$$

$$CaCO_3 = [Q] \times m \times M \times \frac{[C_o]-[-C_a]}{[C_o]} \quad (2)$$

Where:

Q = Calcium acetate concentration (mol/L)

m = Amount of solution (L)

M = Mass of calcium carbonate (100.09)

Co = Initial concentration of calcium ions (g/L)

Ca = Concentration of calcium ions that have been measured (g/L)

In addition, the research scheme was shown in Figure 2.

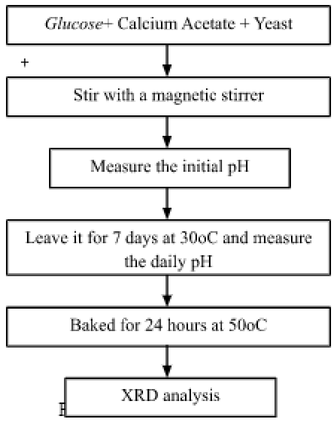

Figure 2 Scheme of research

3. RESULT AND DISCUSSION

The graph shows that at yeast concentrations of 13-22 g/L, calcium ions tend to decrease significantly, which causes the calcium carbonate produced to be proportional to the decrease in calcium ions; however, the resulting precipitate is small. This could be caused by the calcium carbonate that has not precipitated, which has been formed and then wasted with the liquid when it is dried.

At a concentration of 31-40 g/L in a yeast-based biomaterial mixture with a pH of 8.76 distilled water, the highest calcium carbonate precipitates were produced by a yeast concentration of 34 g/L with a final pH of a biomaterial mixture of 5.860. This can occur because a large concentration of yeast causes precipitation to occur more quickly. In contrast to the yeast-based mixture with distilled water pH of 9.09, the concentration of 31 g/L produced the most CaCO3 at the final pH of the yeast-based biomaterial mixture of 5.880.

Thus, it can be concluded that at a concentration of 31-34 g/L with an initial pH of the distilled water used in the range of 8.76-9.09 with a final pH of the mixture of 5.60-5.80 it can produce an optimal calcium carbonate precipitate.

After analysis of the calculations, the optimum composition of the mixed precipitate was obtained as follows:

Table 2. Composition of Solution with Distilled Water

Yeast Concentration (g/L)	Glucose (g/L)	Calcium Acetate Monohydrates	Distilled water pH
g/l	g/l	g/l	
31-34	11.43	8,1	5.60-5.80

On the other hand, if converted into the form of substance molarity, the results for calcium acetate and glucose were obtained as 1.41 mol/L and 1.95 mol/L respectively.

From the XRD analysis, it was determined that calcium carbonate or $CaCO_3$ was present in the precipitate. $CaCO_3$ can be observed in the following graph.

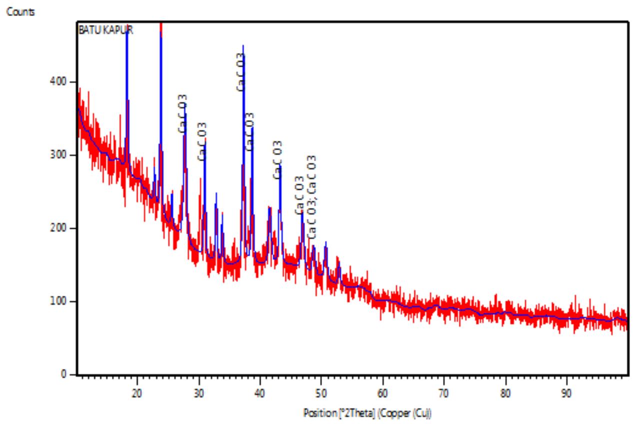

Figure 3 Graph of CaCO3 XRD results

The red peaks in the graph indicate the presence of calcium carbonate or CaCO3. The red peaks in the XRD patterns are called the peaks. The following reads the list of peaks indicating the presence of CaCO3

Peak List

Pos.[°2Th.]	Height [cts]	FWHMLeft[°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.2617	132.62	0.3070	4.85815	61.55
22.7309	34.79	0.3070	3.91207	16.14
23.7701	172.50	0.3070	3.74334	80.05
25.5582	30.92	0.3070	3.48536	14.35
27.6811	127.09	0.5117	3.22271	58.98
30.9183	110.28	0.3070	2.89226	51.18
32.7702	66.25	0.3070	2.73293	30.74
33.7738	47.76	0.3070	2.65398	22.16
37.2202	215.48	0.3070	2.41577	100.00
38.6341	133.91	0.3070	2.33056	62.15
41.4866	54.21	0.5117	2.17667	25.16
43.1682	96.58	0.4093	2.09570	44.82
46.8396	55.40	0.5117	1.93964	25.71
48.6647	28.63	0.5117	1.87108	13.28
50.6060	36.64	0.5117	1.80376	17.00
52.8078	23.94	0.3070	1.73363	11.11

Figure 4 Peak List

The peak, which indicates the presence of CaCO3, was located at headings 18.2617, 23.7710, 27.6811, 30.9183, 37.2202, and 38.6341, with peak heights of 132.62, 172.50, 127.09, 110.28, 215.91, and 133.91, respectively.

4. CONCLUSION

From the research conducted, it can be concluded that:

1. A mixture of yeast and distilled water produces calcium carbonate. However, the pH of the distilled water used must be in the range of 8.76-9.09, with a temperature during precipitation of 30 °C.
2. The optimum composition required to obtain calcium carbonate precipitate from a mixture of yeast-based biomaterials and distilled water is a yeast concentration of 31-34 g/L, glucose of 1.95 mol/L and calcium acetate of 1.41 mol/L with an initial pH Distilled water used is in the range of 8.76-9.09.

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