Making Bioethanol from Food Waste Efficiently with Bioreactors

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Abstract

The purpose of this study is to develop a way to make bioethanol more efficiently than before. In the world, there is a drain on natural resources such as coal and fossil fuels that is gaining global attention. The world needs more renewable resources, so we want to make use of food waste to make bioethanol as an alternative.

1. Introduction

These days, bioethanol attracts attention as a new energy source to reduce the risk of running out of fossil fuel. As of now, it is not a reliable resource because it is difficult to make. To make bioethanol from food waste, you must extract the glucose from the food waste, then add an enzyme to the glucose which transforms the glucose into bioethanol. This process is known as Alcohol-fermentation. We examined the most suitable conditions for making glucose and the best way to make bioreactors. As a result, we established a way to make bioreactors to conduct alcohol-fermentation more effectively.

In this study, we aimed to make bioethanol from starch.
We broke down the starch in rice into glucose using amylase and made bioreactors that contained yeast enzymes and added the bioreactors to the glucose to perform alcohol fermentation. In this way, we made bioethanol from glucose. To make the alcohol fermentation process more efficient we made the yeast enzymes into bioreactors. BBioreactors are defined as a device that uses microorganisms and enzymes as catalysts to synthesize, decompose, and convert substances. Our yeast enzyme bioreactors consisted of yeast enzymes inserted in calcium alginate capsules. By inserting the enzymes into the capsules we were able to reuse them multiple times, since they did not dissolve into the glucose, which we hoped would improve efficiency of the alcohol fermentation process, which we hoped would improve efficiency of the alcohol fermentation process. We conducted various experiments in order to improve the efficiency.

Regarding the process of making the yeast enzyme bioreactor, we had to consider multiple ways of constructing the bioreactor.

The inclusive method was used in this experiment to produce bioreactors which contain yeast. The inclusive method is a method in which enzymes are immobilized in a polymer gel without direct chemical modification by incorporating the enzymes into the gel. Since this method does not involve direct chemical modification[1], which could render the enzyme inactive, we considered it to be a suitable method for bioreactors for yeast. In this

experiment, we used a comprehensive method in which a sodium alginate solution is mixed with yeast and dropped into a calcium chloride solution to form a film on the surface and immobilize the yeast. In this method, sodium alginate reacts with calcium chloride to form insoluble calcium alginate on the surface of the drops, which then becomes a membrane[2].

Next, we will explain the advantage of using bioreactors. We used a bioreactor to reuse the yeast many times. The yeast is covered with a layer which consists of calcium alginate. So it can be taken out from water and dissolved and dissolved after we conclude the experiments.
Next we will explain how to make a bioreactor. In the beginning, we prepared 200g of a 2.0% sodium alginic solution, 1g of dried yeast, 2g of distilled water and a solution containing 20 % calcium chloride.
Then we mixed the dried yeast and distilled water, and added a drop of these substances into the calcium chloride solution. Sodium alginate is water soluble and calcium chloride is insoluble. Wheplets containing sodium alginate come into contact with the calcium chloride solution, the surface gelaten drops to form capsules.

2. Experiment1

2-1 Method

We did experiments in saccharification.
We changed the starch in the rice into glucose.
First, we put rice, koji (an enzyme) and water into five beakers at the ratio of 1:1:3, 0:1:3, 1:1:1, 1:1:2 and 1:1:4 respectively.
Then we put rice, Koji, and water into three beakers at the ratio of 1:1:3, 1:1:10, 1:1:15 respectively to find the most suitable conditions to change starch into glucose.
Second, we kept the beakers at 50℃ and 60℃ for about four days by using a machine which keeps the inside temperature consistent.
Third, we skimmed the top clear layer from the liquid which contained the glucose we would need to test, diluted the solution with ten times the amount of pure water because the concentration of glucose is too high to check.
Fourth, we measured the sugar content by using a measuring instrument which checks the reflective index of the water solution.

2-2 Hypothesis

If we do saccharification at 50℃, then we can produce the most glucose because the temperature
is close to the body temperature.

2-3 Result

These are the results of the experiments.The horizontal axis represents time, the vertical axis represents the concentration of sugar. The rate represents the ratio of rice, koji, and water.

We discovered that saccharification efficiency started to decrease from forty hours in the case of
50℃.
Next, according to Figure2, in the case of 60℃, There was little difference in final saccharification efficiency.

Figure.1

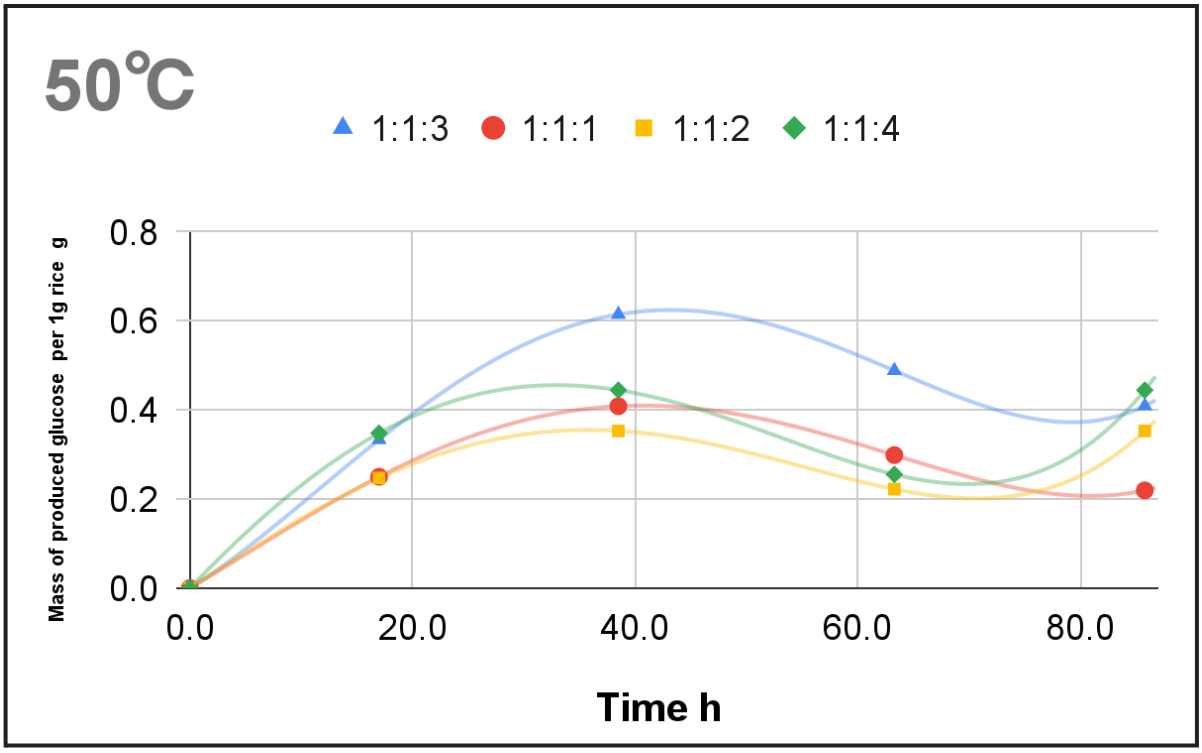
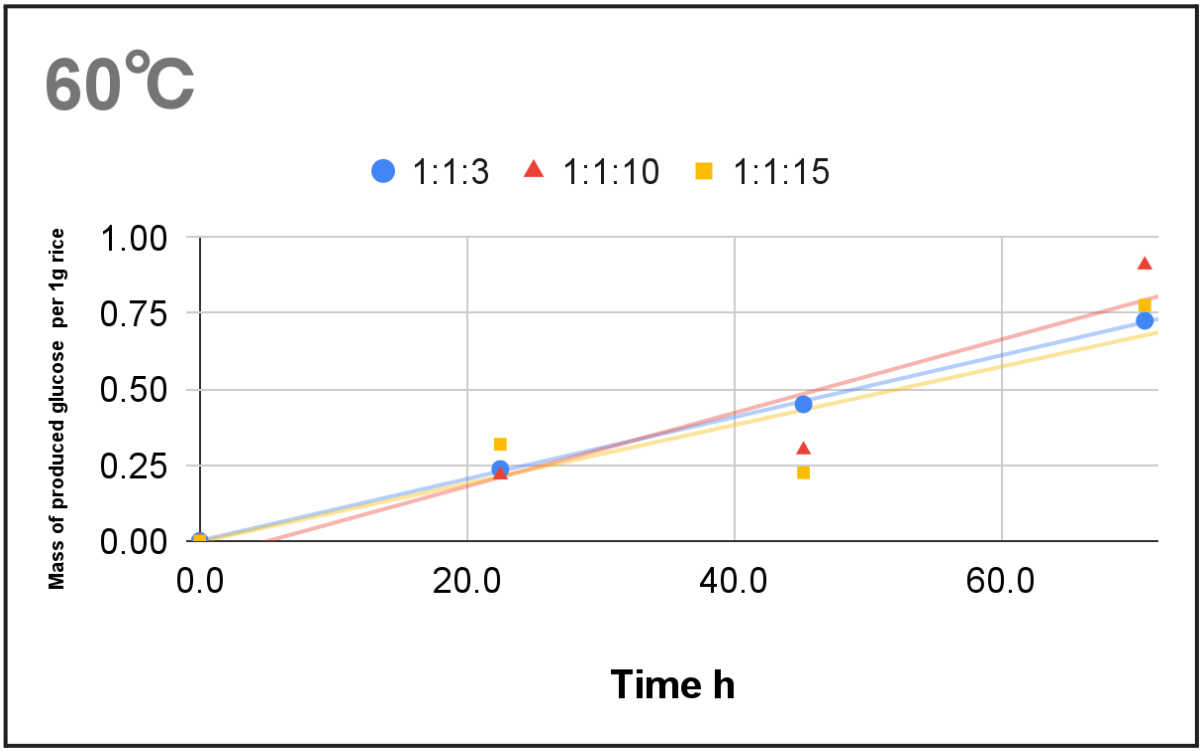


Figure.2



2-4 Conclusion

The rate of rice, koji and water make little difference in saccharification efficiency.
Koji reproduced and consumed glucose in the solution.

3. Experiment2

3-1 Method

We changed the amount of time of putting the bioreactor into the calcium chloride solution. We used intervals of 10 minutes, an hour, three hours, and seven hours. In this experiment, we used 2.0% of sodium alginate solution to make bioreactors and we experimented at 50℃.

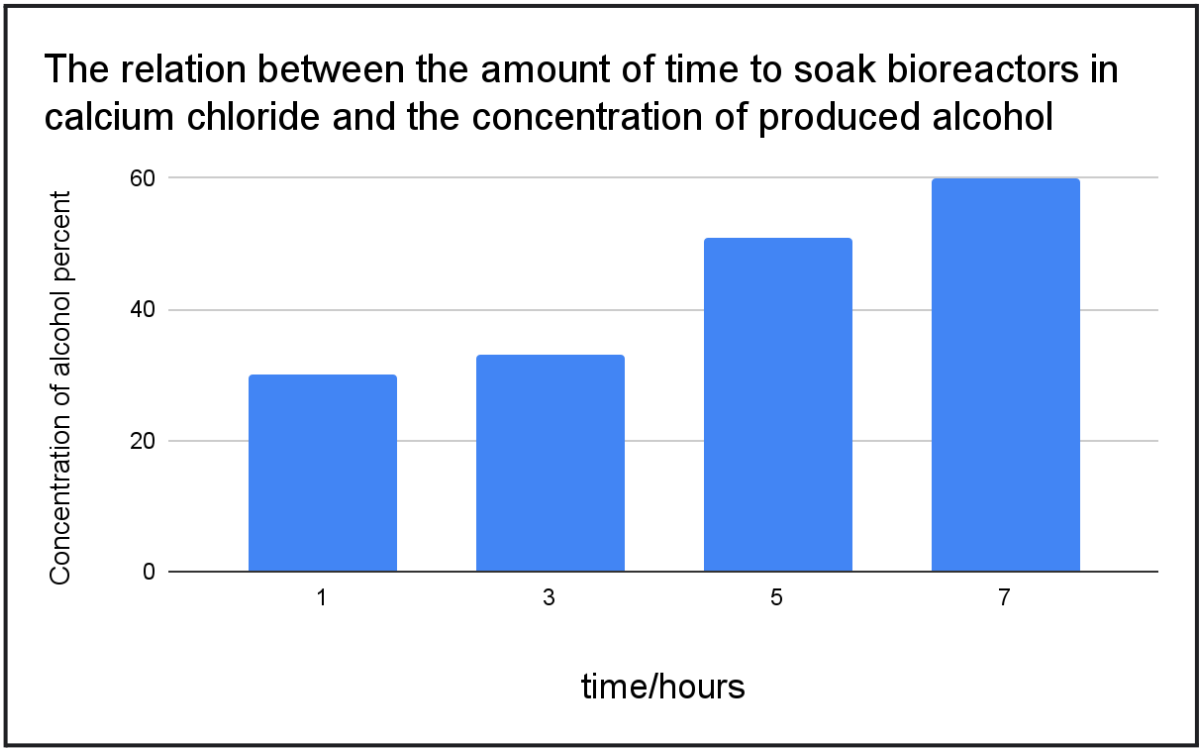
3-2 Hypothesis

If we increase the concentration of calcium chloride solution then the concentration of bioethanol produced would also increase.

3-3 Result

The longer we soaked the bioreactors in the calcium chloride solution, the more bioethanol we could get. (Figure.3)

Figure.3



3-4 Conclusion

The longer we soaked bioreactors in calcium alginate solution, the thicker the membrane of bioreactors became, so we could then continue alcohol fermentation without bioreactors breaking when carbon dioxide is generated inside of bioreactors as a byproduct of the fermentation process.

4. Experiment3

4-1 Method

We changed the concentration of sodium alginate. We used yeast only (not making bioreactors), bioreactors made

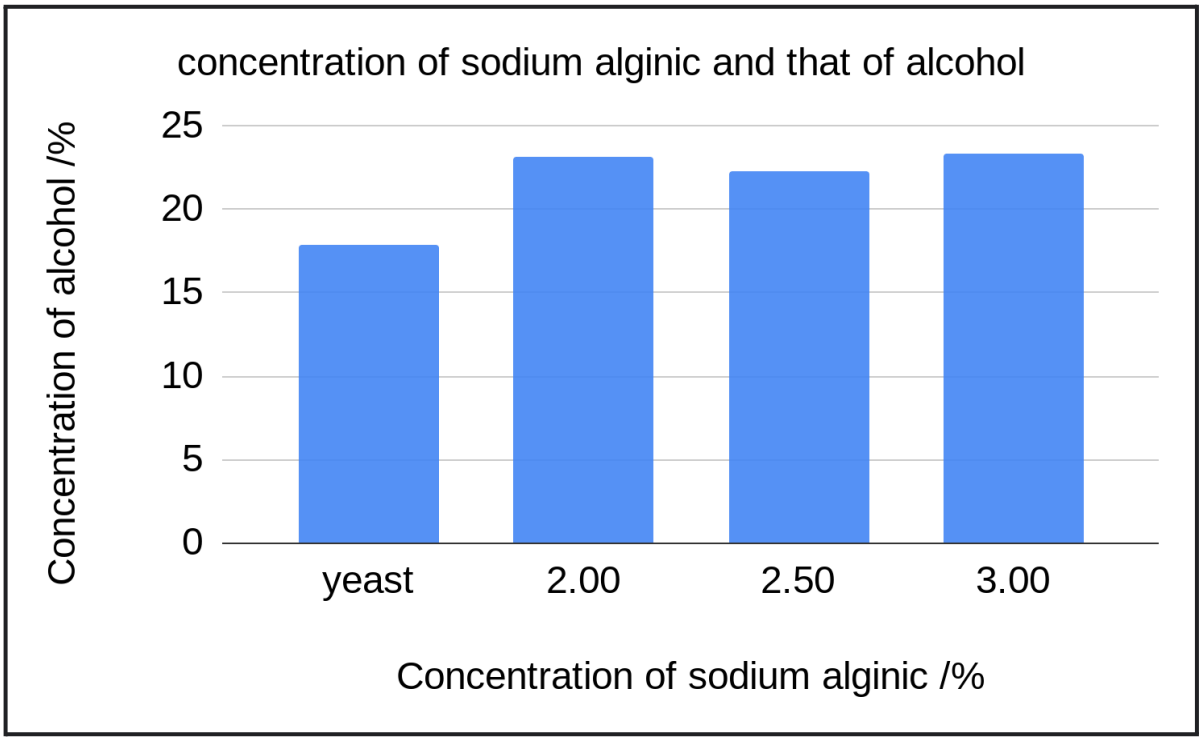
4-2 Hypothesis

Comparing the case of using bioreactors with that of using only yeast, we thought the former was able to produce more ethanol. When we changed the concentration of sodium alginate solution, we thought that we got more etanol.

4-3 Result

We changed the concentration of sodium alginate solution.
We could get more ethanol when we used bioreactors than when we used yeast only: We didn't use the bioreactors. The concentration of alcohol didn't change when we changed the concentration of sodium alginic. (Figure.4)

Figure.4



4-4 Conclusion

When we used a bioreactor, alcohol fermentation was considered to progress relatively more quickly than when we used yeast alone because carbon dioxide is generated in the bioreactor during the alcoholic fermentation, causing the bioreactor to occasionally float and sink, which caused the yeast to more quickly encounter and convert glucose molecules.

5. Experiment4

5-1 Method

We set the temperature when we produce bioethanol from glucose with a bioreactor to check whether the temperature which is suitable when we produce bioethanol changes by using a bioreactor. The temperatures we used were 37 °C, 45 ℃ and 50 ℃.

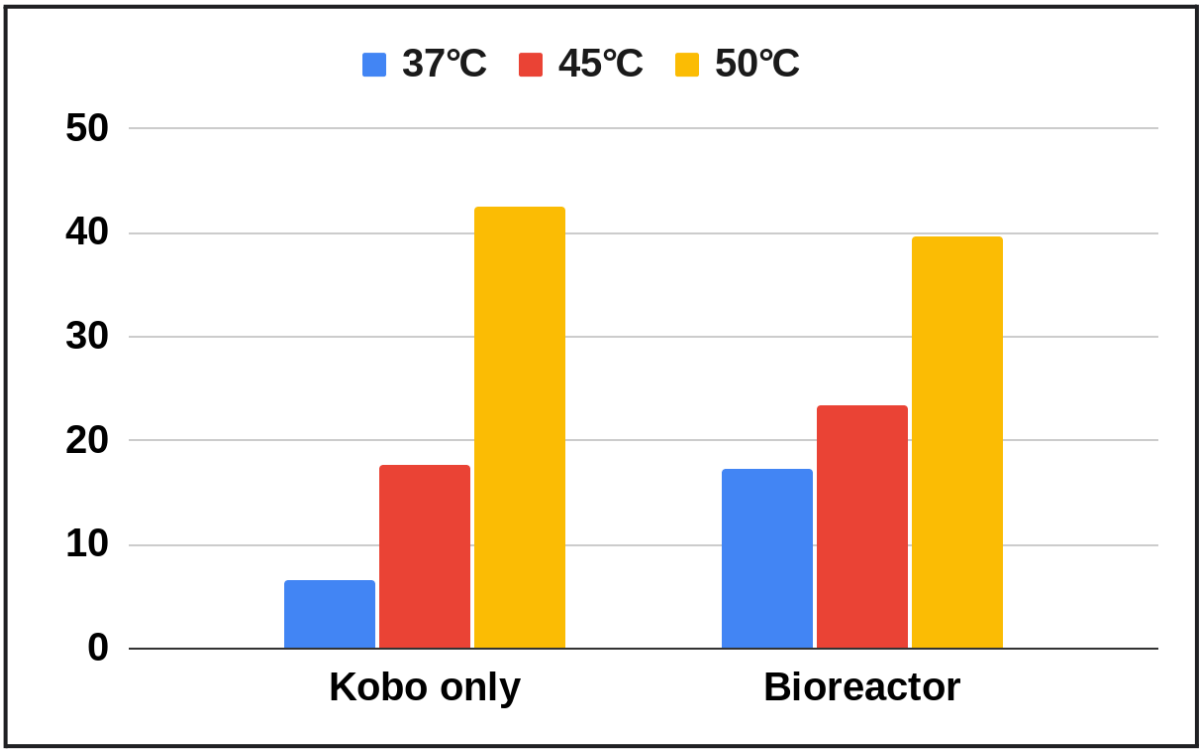
5-2 Hypothesis

We thought that the concentration of alcohol was highest at 45℃ because a previous study of other scientists said that 45℃ is the most suitable temperature to produce bioethanol by using yeast without using bioreactors.

5-3 Result

Unexpectedly, we found that we can produce bioethanol with bioreactor most efficiently when it is 50 ℃. We also realized that the higher the temperature became, the more efficiently we could produce bioreactors.

Figure.5



5-4 Conclusion

According to a previous study of other scientists, 45 ℃ was the most suitable temperature when they produced bioethanol without using bioreactors. However, we could produce bioethanol the most efficiently when it was 50 ℃. We consider that the bioreactor protects yeast inside of it from high temperature so that we need to set the temperature higher than the suitable temperature which was expected in the previous study.

6. Experiment5

6-1 Method

We conducted saccharification and alcohol fermentation in succession. First, conducted saccharification in the same way as experiment 4, and made glucose from rice. Next , we put bioreactors in the glucose solution we made and conducted alcohol fermentation. Last, we measured the concentration of glucose and alcohol.We made sample of different mass rate of Rice, Koji ,and Water. 5.

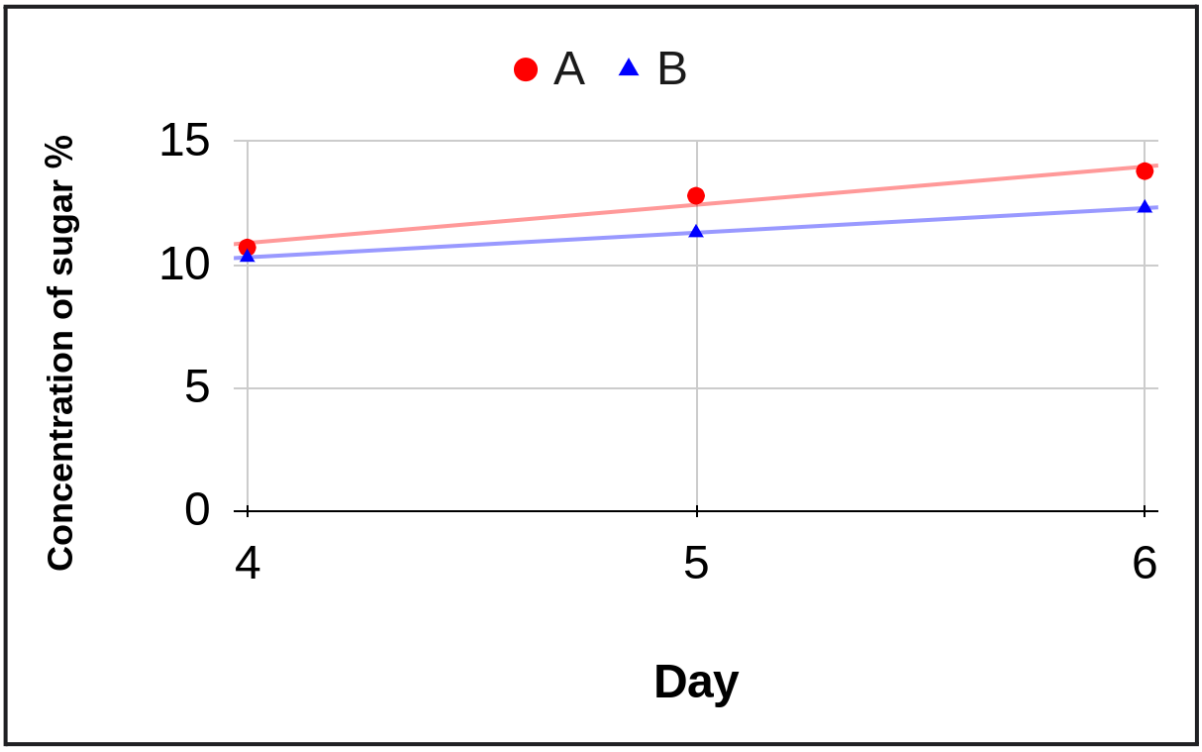
6-2 Hypothesis

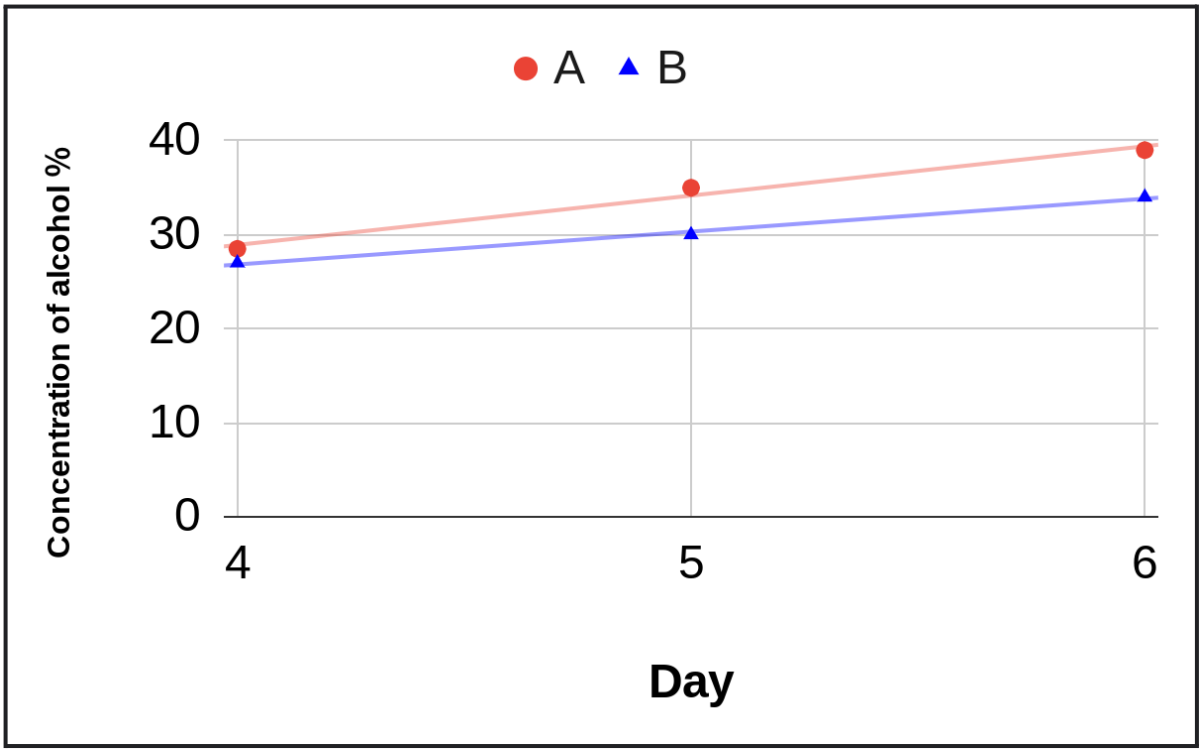
We thought that the concentration of sugar was decreasing and the concentration of alcohol was increasing day by day.

6-3 Result

Both the concentration of sugar and the concentration of alcohol increased.(Figure.6, Figure.7)

Figure.6





6-4 Conclusion

Amylase still remains in the beaker during alcohol fermentation. The amount of sugar content continues to increase. The glucose formed by the amylase is used to continue alcohol fermentation.

7.Prospects for the future

From now on, we will do three things to get better results. First, we will try other alcohol measurement methods which are more accurate to improve reliability of the data because the alcoholic concentration we measured was too high. Second, we will establish and increase efficiency of continuous experiments of glucose production and alcoholic fermentation by changing the temperature, ratio of samples and so on when we conduct the experiments. Third, we will adjust the variables of the experiments. Based on the results of our experiment we will do more experiments, combining the best conditions to produce the most bioethanol efficiently.

8.References

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9.Key words

bioreactor, alcohol fermentation, saccrification