Increasing the Efficiency of Pitorro's Production

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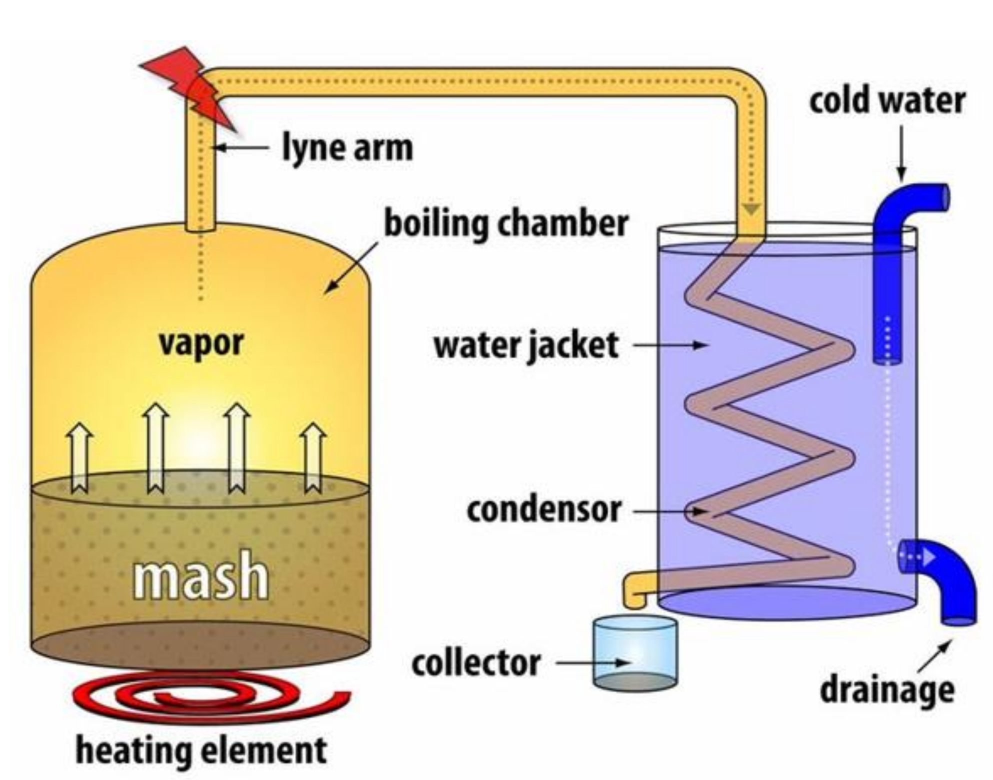
Abstract

Puerto Rico has produced Rum since early ages and is part of its culture. But the rum making process has been an irregular one since the process has been passed through generations and the persons who make it don't really know what's happening in terms of chemistry. Here, we constructed a reflux column system where the process of distillation is more robust, controlled, and efficient. In the end, the new automated systems' production doubled in the same period of time as in the traditional system. In addition, we managed to obtain a consistent high-quality product.

Introduction

Pitorro is known by many names like Cañita, Lágrima de monte (Mountain's tear), Pitrinche, among others, and has always retained its main characteristic, its clandestinity. In the beginning, it was the alcoholic beverage of slaves, farmers, and jíbaros that worked collecting sugar cane and in the sugar mills during the 17 and 18 centuries. It then spread to the whole population, making it very popular. Nowadays it is mainly consumed in the winter season since it has become a very strong Christmas custom. It is said that this is because Pitorro was used in the past by jíbaros to heat their bodies.

How is it produced? Well, like Rum, it is produced from molasses. The molasses are first diluted and mixed with yeast. Yeast ferments the molasses's sugars into alcohol and carbon dioxide, which is released to the air. Once the yeast has completed the fermentation, this "mash", which separates the alcohol from water. This first distillation will result in a liquid that is around 50 to 60% alcohol. It then is distilled up to 3 times, resulting in a liquid that is 80 to 90% alcohol.



Objectives

The purpose of this Thesis is to add controls, safety measures, and increase the efficiency of the distillation process. This will result in a process that is way more efficient in terms of quality, time, and cost.

The main contribution will be demonstrating that alcohol distillation can be done safely efficiently and produce alcohol for fuel purposes. This can be further developed to obtain electricity for homes from an electric generator that can use alcohol as fuel.

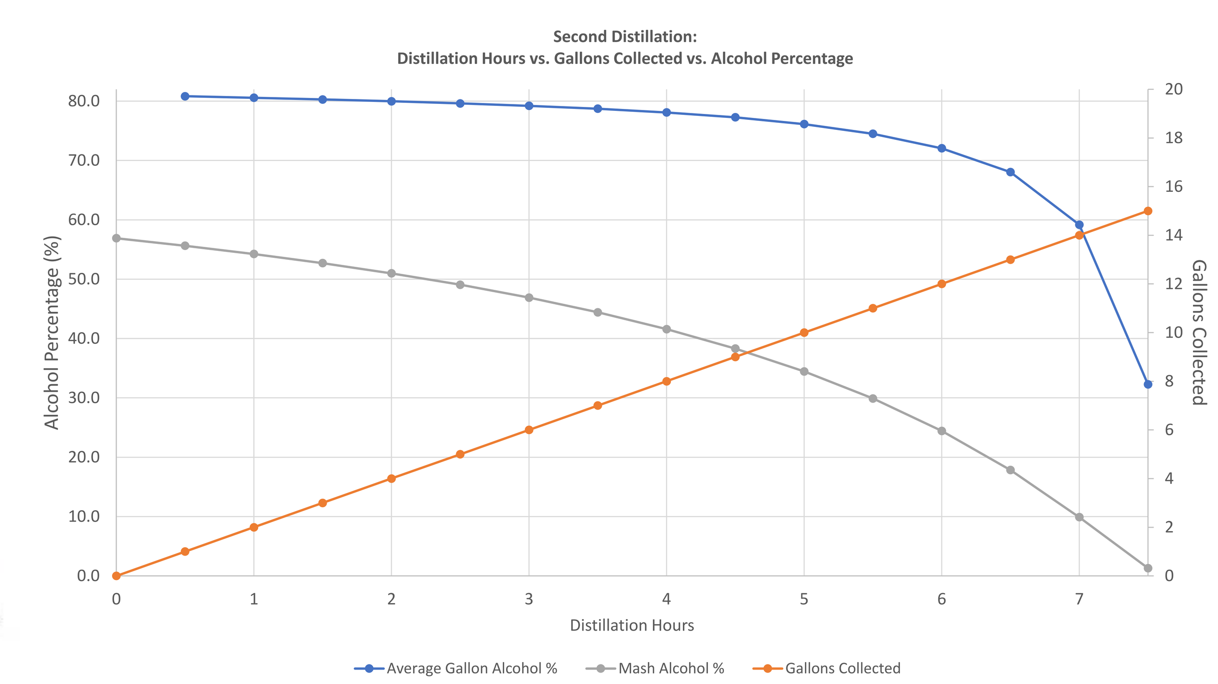
Background

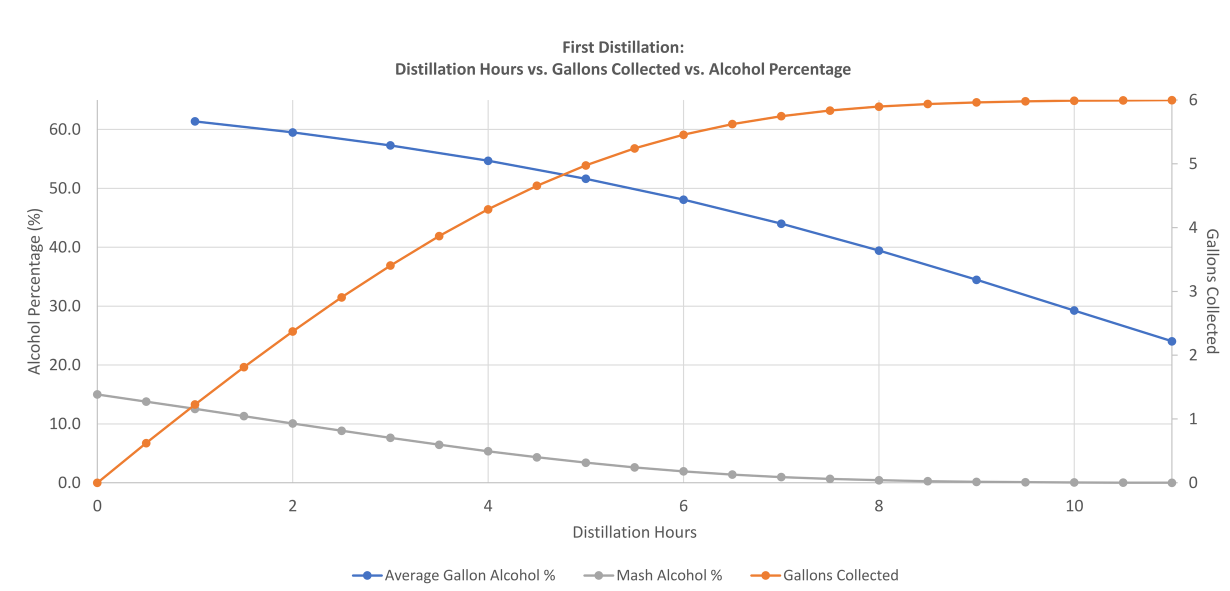
When using the pot still system, we find that the end product's alcohol percentage or proof (another unit of measure for alcohol content) has an inversely proportional relation to the distilling time. Meaning that the first collected drops of alcohol will be the ones with the higher proof, and as time passes, and we continue to collect product (remove alcohol from the mash), the product proof decreases.

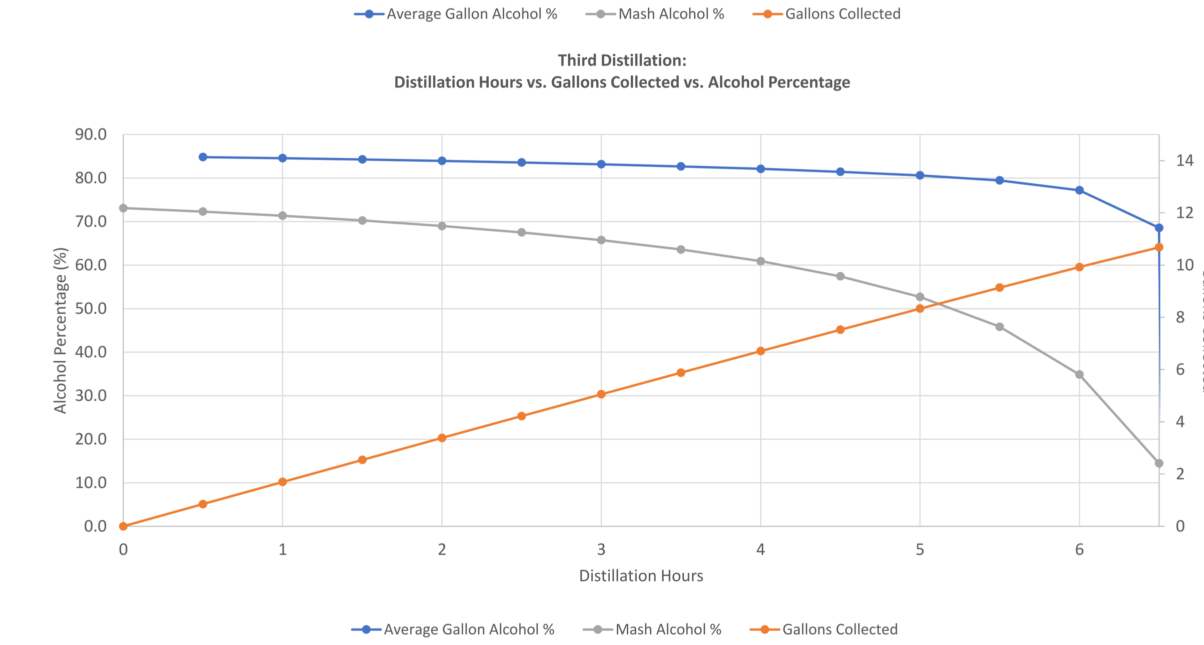
Why this does happen? First, to understand what is happening, we need to know the composition of the mash that we have in the boiler and its physical properties. To better explain the situation, we will assume that we have in the boiler 40 gallons of the fermentation process end product, which is basically 40 gallons composed of 85.0% water and 15.0% alcohol. That's a total of 6 gallons of alcohol.

To do this simulation, I had to first take the data obtained from the Distillation Temperature graph bellow and make a polynomial regression line in Microsoft Excel. This would allow me to know the exact vapor composition when we have a liquid alcohol percentage with one decimal place. To make it exact I had to do a polynomial equation to the ninth power. The exact equation is as follows:

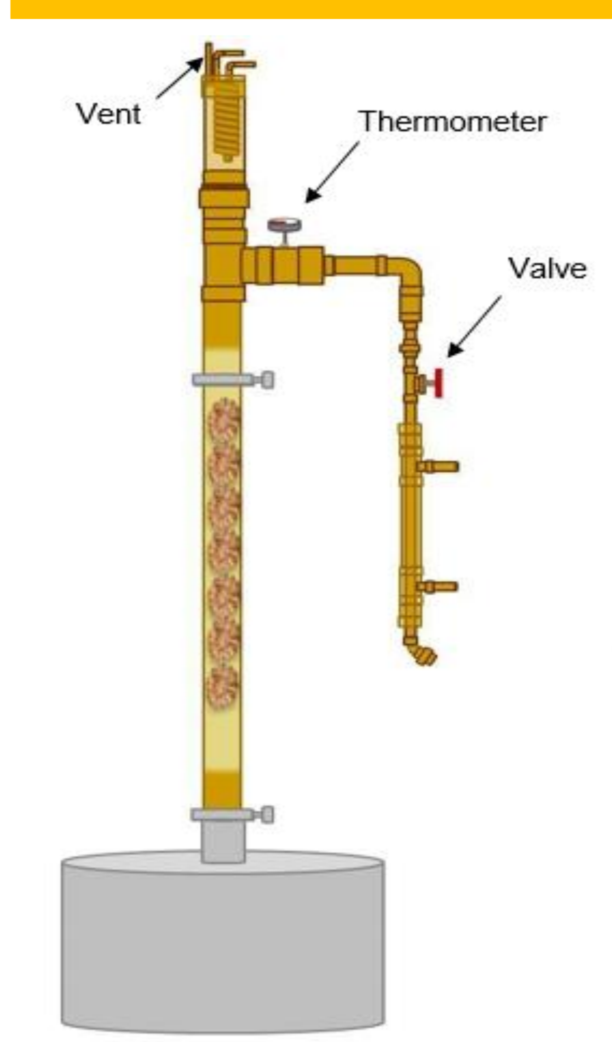
$$y=6.6087E^{16}x^9-1.24144745E^{12}x^8+5.0542768394E^{10}x^7-9.554924205258E^8x^6+1.016955312872030E^5x^5-6.5514062240851100E^4x^4+0.0261675786462708x^3-0.646038874956939x^2+9.713700838556x+0.025143508128771$$







Methodology



What we did in this work was to implement a system that could distill Pitorro more efficiently and cost effective while adding some controls and safety measures. The first change would be the system. Where we changed the distillation equipment. Instead of a pot still as in the Introduction section, we implemented a reflux column still like the one to the left.

On the Top of the column, on the top, is the condenser, where vapors pass through and those vapors condense on contact. The cooling tubes add another reflux element and help this still produce a final product with higher alcohol content. Because of the added reflux elements, most of the alcohol vapor will condense on one of the inert materials in the column and drip back into the boiling chamber. This means that the vapor that does reach the condenser will be much higher in alcohol content than that from a pot still.

To resolve the heating element problem, I used liquid propane instead of firewood. This will allow me to reduce the health and environmental hazard problem and increase my control over the process.

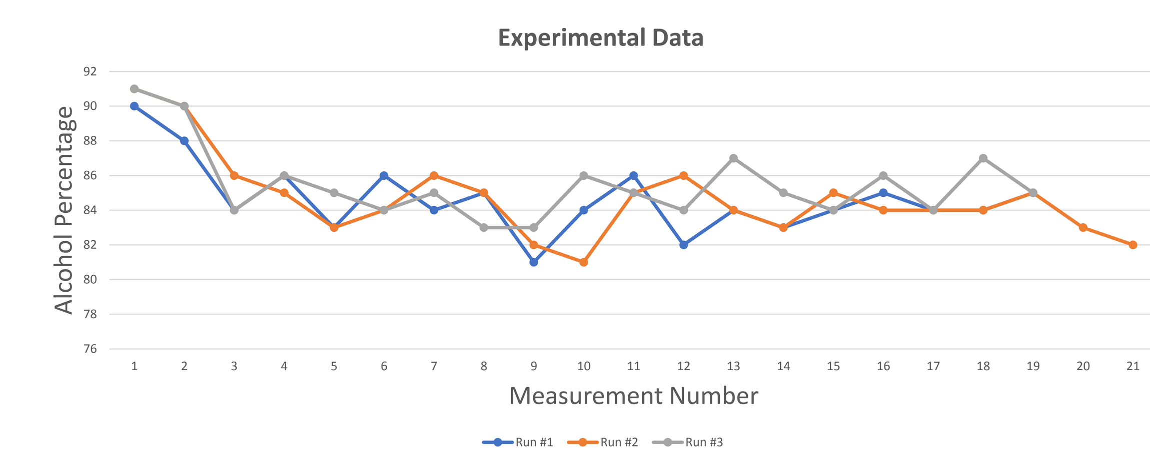
To resolve the alcohol percentage problem, I substituted the valve shown in in the left with a solenoid valve. This valve was controlled by a digital temperature controller, which will monitor the temperature where the thermometer in the Figure at the left is placed.

The digital temperature controller allowed me to set the valve to a certain temperature. This valve allowed me to block the exit of alcohol from the still, forcing it to go back to the boiler. This is known as full reflux and the alcohol that goes through the column again will be redistilled, resulting in a higher alcohol percentage in the output. This action allowed me to get an end product with a high alcohol percentage and save the second and third distillations. The production of good alcohol will be reduced to only one distillation. This will result in huge time and materials savings, which will directly reduce the production costs.

Results and Discussion

To perform this experiment, we changed from firewood to liquid propane as a safety measure. In addition, we constructed a system as described in the Alcohol Percentage section above. We then loaded the system with a mash of approximately 15% alcohol. We calibrated the temperature controller to open the solenoid valve at 80 °C. This temperature would yield liquid alcohol at 85% alcohol.

To validate this experiment, we did it 3 times measuring the alcohol percentage every 15 minutes as allowed by the system.



Conclusion

The system maintained the alcohol percentage through the whole distillation in all 3 experimental runs. Overall, the system did demonstrate that it is more efficiently. The average distillation time was 8 hours. Meaning that four batches would be completed in approximately 32 hours of distillation and resulting in 20 gallons of alcohol with an average of 85% alcohol. Resulting in a total cost of $22.10 per gallon or $5.84 per liter.

Finally, we can now conclude that the process was successfully controlled. The new system permitted to obtain the double amount of good alcohol while doing it in the same period of time. Cutting the production cost by half.

Future Work

To add efficiency to the system we could add a solenoid valve to the propane supply line. This valve will be controlled by a digital temperature controller, which will monitor the temperature from a thermometer in the boiler. With this equipment I can set the valve opening and closing, so when the temperature gets too high, it will allow more gas flow to the burner and adjust the mash temperature.

Another suggestion would be to a flow meter on the output valve. That way we could know what the actual alcohol percentage of the mash is at all times and further tune up the amount of gas needed to boil the mash.

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