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Comparison of Two Methods of Monitoring Corn Mash at Corn Plus Ethanol Plant

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COMPARISON OF TWO METHODS OF MONITORING CORN MASH AT CORN PLUS ETHANOL PLANT

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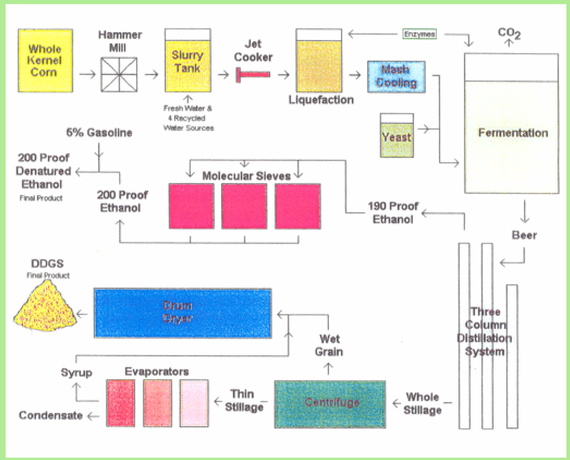
Abstract

In the ethanol industry, several variables affect the amount and grade of ethanol that is produced which affects a plant's ability to make a profit. This research is focused on one of those variables, 'corn mash solid content', which must be closely monitored before the fermentation step. If the mash out of the mix tank is the wrong consistency, the alpha-amylase and gluco-amylase enzymes will not efficiently break the starch into simple sugars that yeast can consume which will decrease the amount of ethanol produced. The mash solid and moisture content is measured daily in order to ensure that the plant will produce on average 2.8 gallons of ethanol for every bushel of corn ground. This places a large significance on the accuracy of the instruments used to analyze these samples.



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This research involved ten days of data collection followed by statistical analysis to compare the accuracy of an infrared light instrument with a forced air drying oven used at Corn Plus Ethanol Plant in Winnebago, MN. The results of this study determined that the two instruments were not consistent with each other. This led to further investigation and consultation with the instrument manufacturer and ultimately the infrared light instrument was re-calibrated. By correcting an instrument that the plant depended on for data, the operators were able to more confidently and efficiently make adjustments throughout ethanol production process and ensure more consistent ethanol quantities and quality.

Introduction

Corn Plus is owned by over 700 local shareholders and began in 1993. Aiming to produce 2.8 gallons of ethanol for every bushel of corn the company processes, several innovations have been added to the progression in the last few years. These innovations have not only improved yield but also the efficiency of the plant. A large portion of the time I have spent in the Corn Plus laboratory has been focused on quality control. I completed several investigations of instruments as well as methods of completing testing, and successfully was able to correct inaccurate data collection. With a multistep production, quality control within the lab plays a major role to ensure the highest grade of ethanol is produced.

10 Day Perten Study

The solid to moisture ratio in each step of process is a simple and fast way to decipher if the production of ethanol is moving forward as it should.

Perten infrared light instrument: allows the fastest method to test solid and moisture content.

Forced air drying oven: ensures more accurate results because you can observe when the sample is dried. Calculation used to determine solid content:

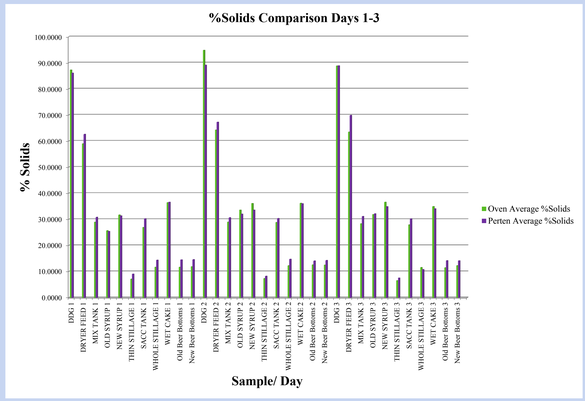
$$\%solids = \frac{(gross - tare)}{sample\ weight} \times 100$$

I conducted a 10 day study comparing the solid/moisture content data from the Perten to that of a forced air drying oven. Each day, I obtained a sample from every step tested throughout process and ran the same sample using both methods. After the ten days, I charted and analyzed the results.

Results Day 1

Sample/ Test Day #	Date	Trial	Oven %Solids	Oven Average %Solids	Perten %Solids	Perten Average %Solids
DDG 1	7/20/2012	1	87.2886	87.2763	86.01	86.1
DDG 1	7/20/2012	2	87.2640		86.19	
DRYER FEED 1	7/20/2012	1	58.7979	58.4649	62.18	62.63
DRYER FEED 1	7/20/2012	2	58.1319		63.08	
MIX TANK 1	7/20/2012	1	17.8956	23.4298	30.9	30.815
MIX TANK 1	7/20/2012	2	28.9640		30.73	
OLD SYRUP 1	7/20/2012	1	25.4258	25.6630	25.26	25.43
OLD SYRUP 1	7/20/2012	2	25.9001		25.6	
NEW SYRUP 1	7/20/2012	1	32.0828	31.7084	31.41	31.365
NEW SYRUP 1	7/20/2012	2	31.3340		31.32	
THIN STILLAGE 1	7/20/2012	1	7.0207	7.1172	9.1	9.09
THIN STILLAGE 1	7/20/2012	2	7.2136		9.08	
SACC TANK 1	7/20/2012	1	27.2287	26.9234	30.35	30.29
SACC TANK 1	7/20/2012	2	26.6180		30.23	
WHOLE STILLAGE 1	7/20/2012	1	11.6367	11.7081	14.27	14.405
WHOLE STILLAGE 1	7/20/2012	2	11.7794		14.54	
WET CAKE 1	7/20/2012	1	36.4699	36.4378	36.58	36.6200
WET CAKE 1	7/20/2012	2	36.4057		36.66	
Old Beer Bottoms 1	7/20/2012	1	11.6605	11.6772	14.52	14.545
Old Beer Bottoms 1	7/20/2012	2	11.6938		14.57	
New Beer Bottoms 1	7/20/2012	1	11.9534	11.9135	14.8	14.605
New Beer Bottoms 1	7/20/2012	2	11.8736		14.41	

The results charted for day 1 (above) and the bar graph of the %solids for days 1-3 (below) illustrate the inconsistency in the Perten instrument I discovered. These results continued to appear in my data for the proceeding 10 days.



Further Analysis: t-Test

After concluding that the results from the Perten were inconsistent with that of the forced air drying oven, I statistically represented my conclusion by performing a t-test I learned how to conduct from reading the analytical chemistry textbook *Quantitative Chemical Analysis.* This test quantitatively shows if the two methods of testing are accurate within 95% confidence.

$$t_{calc} = \frac{|\bar{d}|}{s_{\bar{d}}}\sqrt{n}$$

$$S_d = \sqrt{\frac{\sum(d_i - \bar{d})^2}{n-1}}$$

where $|\bar{d}|$ is the absolute value of the mean difference, so that $t_{calculated}$ is always positive (Harris 62).

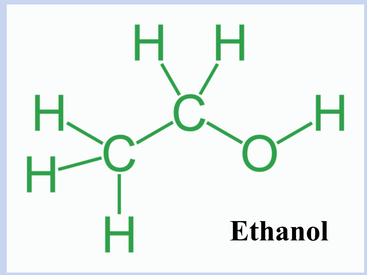
t-Test Results

- Number of samples: 109
- t-calculated: 6.09
- t-table for 120 samples: 1.980

	Confidence Level (%)		
Degrees of Freedom	50%	90%	95%
1	1.000	6.31	12.706
5	0.73	2.02	2.571
10	0.700	1.81	2.228
15	0.69	1.75	2.131
20	0.69	1.73	2.086
25	0.68	1.71	2.060
30	0.68	1.7	2.042
40	0.68	1.68	2.021
60	0.68	1.67	2.000
120	0.68	1.66	1.980
∞	0.67	1.65	1.960

Table 4-2, page 58 of *Quantitative Chemical Analysis*

With these results, my two instruments for data collection do not yield consistent data within a 95% confidence interval.



Conclusions

- The %solids results from the Perten were inconsistent with that of the forced air drying over.
- The forces air drying oven is more accurate than the infrared light method because the change in the moisture in the sample can be visually observed and tested at any stage of drying.
- When accurate, the Perten infrared light instrument allows for a faster method of testing solid/ moisture content.
- t-calculated was 6.09 for 109 samples
- t-table for 120 samples is 1.980
- The two methods of testing did not give the same results within 95% confidence.
- Outside investigations were completed by the manufacturer and they also concluded the Perten instrument inaccurate.
- The Perten infrared light instrument was recalibrated.
- Corn Plus Ethanol Cooperative can now run more confidently and efficiently according to data testing.

Acknowledgements

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Literature Cited

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