

# National Corn-to-Ethanol Research Center



## Summary Report for **Pursuit Dynamics**

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## Appendix A: Description of Analytical Methods

The feedstock and solid coproducts were analyzed using NCERC standard operating procedures (SOP). This appendix provides simple descriptions of the methods that were used for each of these procedures.

### A.1. *Moisture (LMET 20.4)*

Moisture in corn flour and DDG/DDGS is determined by a loss-in-mass method that involves drying at 105 °C for 3 hours in a forced-air oven. This method is based on National Forage Testing Association (NFTA) method 2.2.2.5, which was recently recommended by a study funded by the American Feed Industry Association (AFIA), the Renewable Fuels Association (RFA), and the National Corn Growers Association (NCGA).

### A.2. *Particle-Size Distribution (LMET 18.1)*

The size-distribution of particles in DDG/DDGS and corn flour was determined by sieve analysis. This method involves adding 100 grams of the dry material to the top sieve in a stack of five sieves (No. 16, No. 20, No. 30, No. 40, No. 60; where larger number represents finer mesh size). The sieves are arranged such that the finest mesh screen (No. 60) is at the bottom and the coarsest mesh (No. 16) is at the top. A pan collects all material that passes through the finest screen. The sieves are shaken for 10 minutes in a mechanical sieve shaker. Then, the sieves are separated, and the mass of material remaining on each is measured. The size distribution is reported as the mass fraction of material collected on each sieve.

### A.3. *Starch/Total Fermentable Sugars (LMET 30.1 and 30.2)*

The concentration of total fermentable sugars (referred to as “starch” for simplicity) in corn flour and DDG/DDGS was measured using a procedure that is based on AOAC method 996.11. This method involves a combination of acid and enzymatic hydrolysis of starch and to glucose followed by quantitative analysis of the glucose concentration by high-performance liquid chromatography (HPLC). The distinction between this method and a true “starch” method is that a true starch method would include a washing step designed to remove soluble sugars before the acid digestion step.

Sample analysis involves incubation with 1-N hydrochloric acid at 60 °C, followed by neutralization and digestion with an alpha-amylase enzyme at its optimal temperature (usually 80 to 90 °C) for 90 minutes to extract and convert starch molecules to soluble oligosaccharides. Next, the pH of the slurry is adjusted to about 4.5 and the oligosaccharides are converted to glucose by incubation with a gluco-amylase enzyme at 50 °C for 24 hours. The concentration of glucose is then measured by HPLC.

### A.4. *Crude Protein (LMET 22.2)*

The concentration of crude protein was measured using a combustion procedure based on AOAC method 990.03. This instrumental method was recently recommended by a study funded by the American Feed Industry Association (AFIA), the Renewable Fuels Association (RFA), and the National Corn Growers Association (NCGA). At the NCERC, crude protein is measured by complete combustion of a sample to inorganic products (*e.g.*, NO<sub>x</sub>, SO<sub>x</sub>, CO, CO<sub>2</sub>, and ash) in an atmosphere of oxygen and carbon dioxide using and Elementar Rapid N III. The NO<sub>x</sub> is reduced to N<sub>2</sub>, CO is oxidized to CO<sub>2</sub>, and all other gaseous reactants and products are removed such that the concentration of N<sub>2</sub> in the gas stream can be measured by a thermal-conductivity

detector (TCD). Thus, the concentration of nitrogen in the sample is measured and the concentration of protein is estimated by applying a conversion factor of 6.25 g protein/g N.

#### *A.5. Crude Fat (LMET 19.2)*

Crude fat was measured using a modification of AOAC method 945.16. This method was recently recommended by a study funded by the American Feed Industry Association (AFIA), the Renewable Fuels Association (RFA), and the National Corn Growers Association (NCGA). Crude fat is measured by extraction of the sample with petroleum ether using an automated extraction system (Soxtec Avanti 2050). Samples to be analyzed are weighed into thimbles and inserted into the extraction unit and refluxed with petroleum ether for 6 hours. The solvent is recovered in a tared extraction cup, the solvent is evaporated, and the mass of the residue is measured to determine the concentration of petroleum-ether-extractable material (“crude fat”) in the sample.

#### *A.6. Crude Fiber (QC 3.5.1)*

Crude fiber was measured by a modification of AOAC method 978.10, which was recently recommended by a study funded by the American Feed Industry Association (AFIA), the Renewable Fuels Association (RFA), and the National Corn Growers Association (NCGA). Crude fiber analysis involves extraction of the sample with acetone, hot sulfuric acid, and hot sodium hydroxide in a FOSS Fibertec 2010 semi-automated extraction system. The mass of the residue remaining after extraction is dried, weighed, then completely combusted to ash in a muffle furnace at 550 °C. The mass of the residual ash is determined, and the concentration of the fiber is given the ratio of the mass of volatile (at 550 °C) nonextractable material to the initial sample mass.

Crude fiber was originally intended to provide a measure of the concentrations of lignin plus cellulose, but the ADF method described below (section A.7) is more accurate.

#### *A.7. Acid-Detergent Fiber (ADF; QC 3.1.1)*

Acid-detergent fiber (ADF) was measured using a modification of AOAC method 973.18. This method involves extraction of the sample in an acid-detergent solution for two hours using a FOSS Fibertec 2010 semi-automated extraction system. The nonextractable residue is washed, dried, weighed, combusted to ash at 550 °C, and weighed again. The acid-detergent fiber is given by the ratio of the mass of the nonextractable, volatile (at 550 °C) material to the initial sample mass.

ADF is a measure of the sum of the concentrations of cellulose and lignin.

#### *A.8. Neutral-Detergent Fiber (NDF; QC 3.3.1)*

Neutral-detergent fiber was measured using AOAC method 2002:4. This method involves extraction of the sample with acetone to remove fat, followed by boiling in a neutral-detergent solution for one hour in the presence of a thermostable alpha-amylase enzyme using a FOSS Fibertec 2010 semi-automated extraction system. The nonextractable residue is washed with hot water, dried, weighed, and combusted to ash at 550 °C, and weighed again. The neutral-detergent fiber is given by the ratio of the mass of the nonextractable, volatile (at 550 °C) material to the initial sample mass.

NDF is a measure of the sum of the concentrations of lignin, cellulose, and hemicellulose.

## Appendix B: Derivation of Equation for Final Beer Volume

The volume of the beer ( $V_{\text{beer}}$ ; liters) at the end of fermentation is given by:

$$V_{\text{beer}} = \frac{M_{\text{water}} + C_{\text{EtOH}} V_{\text{beer}}}{\rho_{\text{mix}}} + \frac{C_{\text{ds}} V_{\text{beer}}}{\rho_{\text{ds}}} \quad (\text{B-1})$$

where  $M_{\text{water}}$  (kg) is the final mass of water after correcting for water lost due to starch hydrolysis,  $C_{\text{EtOH}}$  (kg/l) is the final concentration of ethanol,  $C_{\text{ds}}$  (kg/l) is the concentration of nonvolatile dissolved solids in the beer,  $\rho_{\text{mix}}$  is the density of the mixture, and  $\rho_{\text{ds}}$  is the density of the nonvolatile dissolved solids. The mass of water remaining at the end of fermentation is:

$$M_{\text{water}} = M_{\text{water,process}} + M_{\text{water,corn}} - M_{\text{water,hydrolysis}} \quad (\text{B-2})$$

where  $M_{\text{water,process}}$  (kg) is the mass of process water added to the fermentor,  $M_{\text{water,corn}}$  (kg) is the water that entered the fermentor as corn, and  $M_{\text{water,hydrolysis}}$  (kg) is the water consumed during hydrolysis. In this study, the sum of the mass of process water and the mass of water added with the corn were estimated experimentally from the fermentor fill mass,  $M_{\text{fermentor}}$  (kg) and the dry solids concentration of the mash ( $X_{\text{s,mash}}$ ; kg dry solids/kg mash):

$$M_{\text{water,process}} + M_{\text{water,corn}} = M_{\text{fermentor}} (1 - X_{\text{s,mash}}) \quad (\text{B-3})$$

The mass of water consumed during hydrolysis is given by:

$$M_{\text{water,hydrolysis}} = M_{\text{glucose}} - M_{\text{starch}} \quad (\text{B-4})$$

$M_{\text{glucose}}$  (kg) is the mass of glucose produce by hydrolysis of  $M_{\text{starch}}$  (kg) of starch. From the stoichiometry of starch hydrolysis, we know that 1.111 g glucose will be produced per gram of starch that is hydrolyzed. Therefore, the mass of water that is consumed during starch hydrolysis is proportional to the mass of glucose that is produced:

$$M_{\text{water,hydrolysis}} = M_{\text{glucose}} \left( \frac{0.111 \text{ g water/g starch}}{1.111 \text{ g glucose/g starch}} \right) \quad (\text{B-5})$$

Since there is also a stoichiometric relationship between glucose and ethanol, we know that 0.511 g ethanol are produced per gram of glucose, and the mass of water consumed in hydrolysis can be related to the amount of ethanol that is produced:

$$M_{\text{water,hydrolysis}} = M_{\text{EtOH}} \left( \frac{0.111 \text{ g water/g starch}}{(0.511 \text{ g ethanol/g glucose})(1.111 \text{ g glucose/g starch})} \right) \quad (\text{B-6})$$

or:

$$M_{\text{water,hydrolysis}} = C_{\text{EtOH}} V_{\text{beer}} \left( \frac{0.111 \text{ g water/g starch}}{(0.511 \text{ g ethanol/g glucose})(1.111 \text{ g glucose/g starch})} \right) \quad (\text{B-7})$$

Substituting Eqs. (B-2), (B-3), and (B-7) into Eq. (B-1) then simplifying gives:

$$V_{\text{beer}} = \frac{M_{\text{fermentor}}(1 - X_{s,\text{mash}})}{\rho_{\text{mix}} - C_{\text{EtOH}} \left\{ 1 - \left( \frac{0.111}{0.511 * 1.111} \right) \right\} - C_{\text{ds}} \left( \frac{\rho_{\text{mix}}}{\rho_{\text{ds}}} \right)} \quad (\text{B-8})$$

For the purpose of this analysis,  $C_{\text{ds}}$  was assumed to be 0.3 kg/l, which is equal to the value that was observed in a previous pilot-plant trial conducted at the NCERC, and  $\rho_{\text{ds}}$  was assumed to be 1.2 kg/l, which is approximately the density of protein. The density of the ethanol-water mixture ( $\rho_{\text{mix}}$ ) is given by:

$$\rho_{\text{mix}} = 0.1272 * C_{\text{EtOH}}^2 - 0.1848 * C_{\text{EtOH}} + 0.9956 \quad (\text{B-9})$$

which is based on data published in the *Perry's Chemical Engineers' Handbook* for the density of ethanol-water mixtures at 30 °C.

## Appendix C: Raw Data

### C.1. Fermentation Data

#### C.1.1. Controls

##### C.1.1.1. Fermentor R1 (12-02-07 9:30 to 12-04-07 18:25)

time (hrs)	DP4+	DP3	DP2	concentration (g/100 ml)				ethanol	pH
				glucose	lactic acid	glycerol	acetic acid		
6.5	4.3	1.3	2.9	4.2	<0.05	0.08	<0.02	0.11	
14.5	3.2	<0.22	1.9	3.3	<0.05	0.23	<0.02	2.05	5.56
22.5	1.6	<0.22	0.3	2.0	0.05	0.42	<0.02	4.13	4.03
30.5	0.4	<0.22	<0.23	<0.24	0.09	0.54	<0.02	5.62	3.76
38.5	0.2	<0.22	<0.23	<0.24	0.06	0.52	<0.02	5.68	3.83
46.5	<0.23	<0.22	<0.23	<0.24	0.06	0.52	0.04	5.89	3.96
54.5	<0.23	<0.22	<0.23	<0.24	0.05	0.50	0.05	5.80	4.00
57.5	<0.23	<0.22	<0.23	<0.24	0.05	0.50	0.05	5.90	4.00

##### C.1.1.2. Fermentor R2 (12-02-07 17:30 to 12-05-07 03:15)

time (hrs)	DP4+	DP3	DP2	concentration (g/100 ml)				ethanol	pH
				glucose	lactic acid	glycerol	acetic acid		
6.5	5.0	1.3	2.6	3.9	<0.05	<0.08	<0.02	0.15	
14.5	3.3	<0.22	2.0	3.4	<0.05	0.21	<0.02	1.86	4.47
22.5	1.6	<0.22	0.2	2.1	<0.05	0.41	<0.02	3.98	4.00
27.2	0.6	<0.22	0.2	1.1	0.06	0.50	<0.02	4.71	3.82
30.5	0.4	<0.22	<0.23	<0.24	0.08	0.53	0.02	5.40	3.72
38.5	<0.23	<0.22	<0.23	<0.24	0.07	0.51	0.04	5.67	3.86
46.5	<0.23	<0.22	<0.23	<0.24	0.05	0.50	0.04	5.50	3.90

##### C.1.1.3. Fermentor R3 (12-03-07 02:00 to 12-05-07 14:20)

time (hrs)	DP4+	DP3	DP2	concentration (g/100 ml)				ethanol	pH
				glucose	lactic acid	glycerol	acetic acid		
6.0	6.8	1.5	2.0	3.3	<0.05	<0.08	0.02	0.10	5.45
14.0	3.5	<0.22	2.1	4.1	<0.05	0.23	<0.02	1.55	4.54
18.7	2.8	<0.22	0.8	3.4	<0.05	0.37	<0.02	2.72	4.10
22.0	1.9	<0.22	0.3	2.7	<0.05	0.43	<0.02	3.63	4.00
30.0	0.6	<0.22	<0.23	0.6	0.08	0.53	0.02	5.41	3.72
38.0	<0.23	<0.22	<0.23	<0.24	0.10	0.50	0.03	5.60	3.80
49.0	<0.23	<0.22	<0.23	<0.24	0.05	0.50	0.04	5.80	3.90

*C.1.2. Recirculation 1*

*C.1.2.1. Fermentor R4 (12-04-07 13:40 to 12-06-07 17:20)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
18.3	1.9	< 0.22	0.5	1.7	<0.05	0.40	< 0.02	3.90	3.9
26.3	0.6	< 0.22	< 0.23	< 0.24	0.07	0.50	<0.02	5.60	3.70
30.3	0.4	< 0.22	< 0.23	< 0.24	0.05	0.57	<0.02	5.56	3.80
34.3	0.3	< 0.22	< 0.23	< 0.24	0.06	0.54	<0.02	5.64	3.80
38.3	0.2	< 0.22	< 0.23	< 0.24	0.05	0.57	<0.02	5.55	3.90
42.3	< 0.23	< 0.22	< 0.23	< 0.24	0.05	0.51	<0.02	5.80	3.90
46.3	< 0.23	< 0.22	< 0.23	< 0.24	0.05	0.57	<0.02	5.85	3.95

*C.1.2.2. Fermentor R5 (12-05-07 06:00 to 12-07-07 08:00)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
2.0	5.7	1.7	2.6	4.2	<0.05	16.0	< 0.02	< 0.07	5.2
10.0	3.1	< 0.22	2.7	3.8	0.08	0.13	< 0.02	1.20	4.40
14.0	2.9	< 0.22	1.6	2.4	0.06	0.29	< 0.02	2.70	4.00
18.0	2.1	< 0.22	0.6	1.4	0.05	0.36	< 0.02	3.70	3.90
22.0	1.1	< 0.22	< 0.23	0.4	0.05	0.46	< 0.02	4.80	3.70
26.0	0.5	< 0.22	< 0.23	< 0.24	0.05	0.45	< 0.02	5.20	3.80
30.0	0.3	< 0.22	< 0.23	< 0.24	0.05	0.46	< 0.02	5.40	3.80
38.0	< 0.23	< 0.22	< 0.23	< 0.24	0.05	0.46	< 0.02	5.20	3.90
46.0	< 0.23	< 0.22	< 0.23	< 0.24	0.05	0.42	< 0.02	5.20	3.90

*C.1.2.3. Fermentor R6 (12-05-07 18:25 to 12-08-07 01:55)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
1.6	7.30	2.10	2.00	3.10	0.05	< 0.08	< 0.02	< 0.65	5.40
5.6	4.50	1.70	2.50	3.90	0.05	< 0.08	< 0.02	0.06	5.20
9.6	3.20	< 0.22	3.10	4.30	0.07	0.12	< 0.02	0.90	4.50
13.6	3.00	< 0.22	2.00	2.50	0.05	0.28	< 0.02	2.50	4.50
17.6	2.50	< 0.22	0.90	1.40	0.05	0.37	< 0.02	3.70	4.50
25.6	0.70	< 0.22	< 0.23	< 0.24	0.05	0.51	< 0.02	5.40	3.70
33.6	0.40	< 0.22	< 0.23	< 0.24	0.05	0.54	< 0.02	5.60	3.80
41.6	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.52	< 0.02	5.56	
55.5	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.53	< 0.02	5.65	



C.1.3. Recirculation 2

C.1.3.1. Fermentor R7 (12-07-07 16:05 to 12-10-07 02:10)

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
3.9	2.5	1.4	2.0	3.0	< 0.05	< 0.08	< 0.02	< 0.65	5.5
11.9	2.1	ND	1.5	2.2	< 0.05	0.23	< 0.02	1.78	4.35
19.9	0.7	< 0.22	< 0.23	0.5	< 0.05	0.33	< 0.02	3.74	3.89
27.9	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.35	0.04	4.21	3.90
35.9	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.35	0.05	4.20	3.90
43.9	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.36	< 0.02	4.17	4.19
51.9	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.357	< 0.02	4.17	4.24
58.1	5.0	< 0.23	< 0.22	< 0.23	< 0.05	0.36	< 0.02	4.21	4.29
58.6	8.1	< 0.23	< 0.22	< 0.23	< 0.05	0.36	< 0.02	4.20	4.29

C.1.3.2. Fermentor R8 (12-08-07 09:50 to 12-10-07 14:15)

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
2.2	5.81	1.87	1.71	2.45	< 0.05	< 0.08	< 0.02	< 0.65	5.90
10.2	2.54	0.22	1.66	3.99	< 0.05	0.17	0.05	1.11	4.66
18.2	1.09	< 0.22	< 0.23	1.45	0.05	0.34	< 0.02	3.69	3.93
26.2	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.40	< 0.02	4.79	3.86
34.2	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.40	< 0.02	4.78	4.01
42.2	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.39	< 0.02	4.70	4.16
50.2	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.39	< 0.02	4.49	4.20
52.5	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.369	< 0.02	4.54	4.21

C.1.3.3. Fermentor R9 (12-09-07 12:40 to 12-11-07 16:15)

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
7.3	3.83	0.93	2.84	4.52	< 0.05	< 0.08	< 0.02	0.34	4.18
15.3	3.05	< 0.22	1.33	2.23	0.05	0.3	< 0.02	3.10	4.18
23.3	1.15	< 0.22	< 0.23	0.43	0.07	0.5	< 0.02	5.13	3.78
31.3	0.40	< 0.22	< 0.23	< 0.24	< 0.05	0.51	< 0.02	5.55	3.85
39.3	0.32	< 0.22	< 0.23	< 0.24	< 0.05	0.50	< 0.02	5.69	3.94
47.3	0.25	< 0.22	< 0.23	< 0.24	< 0.05	0.50	< 0.02	5.74	3.96
51.7	< 0.23	2.40	< 0.23	< 0.24	< 0.05	0.50	< 0.02	5.81	4.01
52.3	< 0.23	< 0.22	< 0.23	< 0.24	< 0.05	0.45	< 0.02	5.36	4.02

*C.1.4. Ethanol Reactor Tower*

*C.1.4.1. Fermentor R12 (12-14-07 04:00 to 12-15-07 19:30)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
0.5	10.03	1.80	1.31	1.78	<0.05	<0.08	<0.02	<0.065	
8.0	3.67	0.48	3.20	5.13	<0.05	<0.08	<0.02	0.70	
14.7	3.17	<0.22	1.87	2.43	<0.05	0.28	<0.02	2.94	
15.3	3.0	<0.22	1.4	2.2	<0.05	0.31	<0.02	3.23	
24.0	1.5	<0.22	<0.23	0.7	<0.05	0.42	<0.02	5.14	
32.0	0.4	<0.22	<0.23	<0.24	<0.05	0.43	<0.02	5.76	
36.0	0.3	<0.22	<0.23	<0.24	<0.05	0.43	<0.01	5.77	
39.6	0.3	<0.22	<0.23	<0.24	<0.05	0.419	<0.020	5.82	
40.1	0.3	<0.22	<0.23	<0.24	<0.05	0.418	<0.02	5.81	

*C.1.4.2. Fermentor R13 (12-14-07 13:30 to 12-16-07 13:50)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
-1.5	10.22	1.66	1.01	0.70	<0.05	<0.08	<0.02	<0.065	
5.8	4.14	1.58	2.33	4.04	<0.05	<0.08	<0.02	0.19	
14.5	3.10	<0.22	1.86	2.48	<0.05	0.3	<0.02	2.50	
22.5	1.57	<0.22	<0.23	1.18	0.09	0.45	<0.02	4.53	
30.5	0.46	<0.22	<0.23	<0.24	0.12	0.52	<0.02	5.57	
38.5	0.26	<0.22	<0.23	<0.24	0.09	0.51	<0.02	5.61	
46.5	<0.23	<0.22	<0.23	<0.24	0.06	0.52	<0.02	5.68	
48.4	<0.23	<0.22	<0.23	<0.24	0.05	0.51	<0.02	5.77	

*C.1.4.3. Fermentor R14 (12-15-07 02:00 to 12-17-07 02:00)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
4.0	6.01	1.64	1.95	4.18	0.09	<0.08	<0.02	0.08	
10.0	3.08	<0.22	2.08	5.00	<0.05	0.1	<0.02	1.20	
18.0	2.38	<0.22	0.30	1.46	0.13	0.4	<0.02	4.20	
26.0	0.82	<0.22	<0.23	<0.24	0.14	0.45	<0.02	5.53	
34.0	0.33	<0.22	<0.23	<0.24	0.10	0.46	<0.02	5.73	
42.0	<0.23	<0.22	<0.23	<0.24	0.08	0.46	0.0	5.81	
46.0	<0.23	<0.22	<0.23	<0.24	0.07	0.45	0.038	5.87	
48.3	<0.23	<0.22	<0.23	<0.24	0.07	0.45	0.042	5.84	

*C.1.5. Ethanol Reactor Tower (27% dry solids)*

*C.1.5.1. Fermentor R15 (12-15-07 16:30 to 12-17-07 16:35)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
3.5	8.79	2.32	2.98	6.51	0.41	<0.08	0.03	0.15	
11.5	5.40	<0.22	3.06	5.68	0.35	0.43	0.02	3.25	
19.5	2.20	<0.22	0.27	<0.24	0.37	0.89	<0.02	7.83	
27.5	0.7	<0.22	<0.23	<0.24	0.23	0.89	<0.02	8.34	
31.5	0.5	<0.22	<0.23	<0.24	0.18	0.88	0.03	8.54	
39.5	0.4	<0.22	<0.23	<0.24	0.12	0.89	0.05	8.64	
46.0	0.2	<0.22	<0.23	<0.24	0.08	0.88	0.07	8.38	
47.5	0.2	<0.22	<0.23	<0.24	0.068	0.88	0.072	8.70	
48.1	0.3	<0.22	<0.23	<0.24	0.08	0.894	0.07	8.77	
48.7	0.3	<0.22	<0.23	<0.24	0.11	0.891	0.06	8.96	

*C.1.5.2. Fermentor R16 (12-16-07 07:05 to 12-18-07 06:45)*

time (hrs)	concentration (g/100 ml)								
	DP4+	DP3	DP2	glucose	lactic acid	glycerol	acetic acid	ethanol	pH
4.9	15.81	2.26	1.62	2.98	<0.05	<0.08	<0.02	<0.065	
12.9	6.44	<0.22	3.96	8.81	0.28	0.2	<0.02	1.13	
16.9	5.76	<0.22	2.26	7.37	0.31	0.3	<0.02	3.10	
24.9	4.49	<0.22	0.64	4.26	0.32	0.64	<0.02	5.97	
30.9	2.48	<0.22	0.27	2.57	0.31	0.74	<0.02	7.37	
32.9	2.18	<0.22	0.28	1.97	0.29	0.75	<0.02	8.10	
40.9	0.83	<0.22	0.24	0.13	0.21	0.78	<0.02	9.34	
47.7	0.54	<0.22	0.23	<0.24	0.17	0.79	<0.02	9.68	
48.4	0.584	<0.22	0.24	<0.24	0.16	0.792	<0.02	9.67	

## C.2. Saccharification Data

### C.2.1. Controls

#### C.2.1.1. Slurry Tank (TA-990)

date	time	fermentor	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/2/2007	7:00	R1	5.64	10.8	15.9	12.4
12/2/2007	11:00	R1	5.75	12.5	15.4	12.6
12/2/2007	15:00	R1	6	10.8	15.0	12.4
12/2/2007	17:00	R2		9.3		
12/2/2007	19:00	R2	5.96	8.7	14.7	12.1
12/2/2007	21:00	R2		11.5		
12/2/2007	23:00	R2	5.91	9.2	15.9	12.3
12/3/2007	3:00	R3	5.98	7.0	15.6	13.4

#### C.2.1.2. Liquefaction (TA-1220)

date	time	fermentor	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/2/2007	9:30	R1	5.89	26.8	17.0	12.6
12/2/2007	13:30	R1	6.03	24.3	16.7	12.7
12/2/2007	17:30	R2	5.98	19.5	16.4	12.3
12/2/2007	21:30	R2	6.05	9.2	15.9	11.1
12/3/2007	1:30	R3	5.54	13.8	16.7	
12/3/2007	5:30	R3	5.86	14.1	15.4	11.9

C.2.2. *Recirculation 1*

C.2.2.1. *Tank A (Sample Port TA)*

C.2.2.1.1. *Fermentor R4*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/4/2007	3:00	1.00	6.05	2.1	22.0	17.9
12/4/2007	4:00	2.00	5.91	7.0	16.7	14.6
12/4/2007	6:00	4.00	5.88	3.1	14.3	14.6
12/4/2007	7:00	5.00		2.4	15.6	14.4

C.2.2.1.2. *Fermentor R5*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/4/2007	15:50	0.00				
12/4/2007	17:50	2.00	5.72	5.8	15.7	13.6
12/4/2007	19:50	4.00	5.56	6.6	16.9	14
12/4/2007	21:15	5.42	5.56			

C.2.2.1.3. *Fermentor R6*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/5/2007	7:30	1.00	6.01	1.4	8.1	6.2
12/5/2007	8:30	2.00	5.57	2.9	8.5	6.1
12/5/2007	10:30	4.00	5.66	5.7	14.2	13.8
12/5/2007	11:30	5.00	5.68	5.6	14.9	8.0

C.2.2.2. *Heat and Transfer (Sample Port TAP)*

C.2.2.2.1. *Fermentor R4*

date	time	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/4/2007	8:47	1.43	65	5.9	14.3	12.4
12/4/2007	9:05	1.73	70	8.2	14.2	13.2
12/4/2007	9:17	1.93	75	10.5	14.7	13.3
12/4/2007	9:42	2.35	80	15.6	14.5	13.0
12/4/2007	10:01	2.67	84	19.6	14.9	12.6
12/4/2007	10:06	2.75	83.5	20.3	15.2	13.1
12/4/2007	10:11	2.83	84.2	19.5	15.1	12.5
12/4/2007	10:16	2.92	84.4	19.7	15.1	12.6

*C.2.2.2.2. Fermentor R5*

date	time	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/4/2007	23:30	1.63	65	5.8	15.9	12.6
12/4/2007	23:43	1.85	70	7.7	16.4	12.5
12/4/2007	23:56	2.07	75	10.1	16.3	13.5
12/5/2007	0:22	2.50	80	16.5	15.2	12.4
12/5/2007	0:44	2.87	83.2	18.5	15.6	12.3
12/5/2007	0:49	2.95	83.4	23.1	15.4	12.0
12/5/2007	0:54	3.03	83.9	N/R	15.1	11.9
12/5/2007	0:59	3.12	84.3	22.0	14.8	12.5

*C.2.2.2.3. Fermentor R6*

date	time	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/5/2007	13:34	1.57	65	5.9	14.4	12.4
12/5/2007	13:49	1.82	70	6.6	14.1	12.3
12/5/2007	14:05	2.08	75	11.9	14.4	13.3
12/5/2007	14:25	2.42	80	15.9	14.7	12.3
12/5/2007	14:50	2.83	83.3	20.5	14.6	12.3
12/5/2007	14:55	2.92	83.5	19.2	14.7	12.1
12/5/2007	15:00	3.00	83.4	21.0	14.8	12.4
12/5/2007	15:05	3.08	83.7	20.2	14.4	11.8

*C.2.2.3. Tank B Effluent (Sample Port MC)*

*C.2.2.3.1. Fermentor R4*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/4/2007	13:10	3.32	5.76	26	15.1	11.8
12/4/2007	14:40	4.82	5.83	26	14.9	11.6
12/4/2007	16:40	6.82	5.8	28	15.3	11.7
12/4/2007	18:40	8.82			15.6	

*C.2.2.3.2. Fermentor R5*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/5/2007	5:30	4.93	5.22	26		
12/5/2007	6:15	5.68	5.33	26	15.1	12.2
12/5/2007	8:15	7.68	5.17	28	15.4	11.7
12/5/2007	10:15	9.68	5.21	20.5		

*C.2.2.3.3. Fermentor R6*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/5/2007	17:50	3.17	5.09	27.0	14.5	11.2
12/5/2007	19:25	4.75	5.07	24.4	15.1	11.4
12/5/2007	21:25	6.75	5.19	24.6	15.1	11.4
12/5/2007	23:25	8.75	5.32	22.1	13.7	9.1

*C.2.3. Recirculation 2*

*C.2.3.1. Tank A (Sample Port TA)*

*C.2.3.1.1. Fermentor R7*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/7/2007	6:30	2.00	6.03	3.82	14.6	13.35
12/7/2007	8:30	4.00	5.93	1.45	12.8	13.15

*C.2.3.1.2. Fermentor R8*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/8/2007	0:15	2.00	6.67	1.94	13.3	14.2*

*C.2.3.1.3. Fermentor R9*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/9/2007	4:10	2.00	5.75	3.3	9.6	8.46
12/9/2007	6:10	4.00	5.89	4.0	19.7	16.58

*C.2.3.2. Heat and Transfer (Sample Port TAP and TBI)*

*C.2.3.2.1. Fermentor R7*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/7/2007	11:49	TAP	1.57	60	4.73	11.5	9.32
12/7/2007	12:07	TAP	1.87	65	4.93	12.7	10.05
12/7/2007	12:24	TAP	2.15	70	5.48	12.9	10.94
12/7/2007	12:36	TAP	2.35	75	8.42	11.3	10.66
12/7/2007	12:46	TBI	2.52	83.8	10.69	11.7	10.60
12/7/2007	12:51	TBI	2.60	84.1	12.51	12.3	10.17
12/7/2007	12:56	TBI	2.68	81.1	13.55	11.1	9.73
12/7/2007	13:01	TBI	2.77	81.4	13.41	11.3	8.78

*C.2.3.2.2. Fermentor R8*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/8/2007	5:39	TAP	1.37	60	5.43	12.3	10.70
12/8/2007	5:57	TAP	1.67	65	6.62	10.9	11.10
12/8/2007	6:10	TAP	1.88	70	6.21	12.7	11.10
12/8/2007	6:19	TAP	2.03	75	8.06	12.7	10.80
12/8/2007	6:29	TBI	2.20	84.9	8.91	13.2	11.00
12/8/2007	6:34	TBI	2.28	85	9.39	12.8	11.40
12/8/2007	6:39	TBI	2.37	84.7	16.34	12.3	10.50
12/8/2007	6:44	TBI	2.45				

*C.2.3.2.3. Fermentor R9*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/9/2007	10:20	TAP	1.33	60	5.1	15.2	13.39
12/9/2007	10:36	TAP	1.60	65	6.1	14.5	14.03
12/9/2007	10:53	TAP	1.88	70	6.8	15.6	14.16
12/9/2007	11:07	TAP	2.12	74	9.1	16.2	13.92
12/9/2007	11:17	TBI	2.28	83	9.2	16.2	13.97
12/9/2007	11:22	TBI	2.37	84.5	9.9	16.1	13.54
12/9/2007	11:27	TBI	2.45	84.7	11.7	15.9	13.30
12/9/2007	11:32	TBI	2.53	84.9	12.4	15.6	13.20

*C.2.3.3. Tank B Effluent (Sample Port MC)*

*C.2.3.3.1. Fermentor R7*

date	time	port	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/7/2007	15:35	MC	2.98	5.87	24.04	11.7	9.07
12/7/2007	17:05	MC	4.48	5.83	25.13	11.6	9.32
12/7/2007	19:05	MC	6.48	5.90	26.47	12.1	9.40
12/7/2007	21:05	MC	8.48	5.82	28.56	10.6	9.19
12/7/2007	15:35	TBE	2.98	5.87	23.36	12.1	9.66
12/7/2007	17:05	TBE	4.48	5.83	25.52	11.7	9.32
12/7/2007	19:05	TBE	6.48	5.90	25.12	11.6	9.60
12/7/2007	21:05	TBE	8.48	5.82	29.03	10.7	9.60



*C.2.3.3.2. Fermentor R8*

date	time	port	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/8/2007	9:18	MC	2.98	5.96	20.43	13.3	11.00
12/8/2007	10:48	MC	4.48	5.71	25.86	12.2	11.50
12/8/2007	9:18	TBE	2.98	5.96	22.04	13.1	10.90
12/8/2007	10:48	TBE	4.48	5.71	25.58	12.4	11.10

*C.2.3.3.3. Fermentor R9*

date	time	port	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/9/2007	11:50	MC	0.72	5.67	14.6	15.6	12.12
12/9/2007	13:20	MC	2.22	5.59	19.1	15.3	12.39
12/9/2007	15:20	MC	4.22	5.57	26.3	14.8	12.71
12/9/2007	17:20	MC	6.22	5.57	27.2	14.3	12.68
12/9/2007	11:50	TBE	0.72	5.67	14.8	16.2	12.35
12/9/2007	13:20	TBE	2.22	5.59	19.1	15.8	13.5
12/9/2007	15:20	TBE	4.22	5.57	23.6	15.6	12.74
12/9/2007	17:20	TBE	6.22	5.57	27.1	14.6	12.91

*C.2.4. Ethanol Reactor Tower*

*C.2.4.1. Tank A (Sample Port TA)*

*C.2.4.1.1. Fermentor R12*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/13/2007	15:26	1.00	6.12	2.0	20.6	18.23
12/13/2007	16:26	2.00	5.88	5.3	18.1	14.8
12/13/2007	18:26	4.00	5.8	6.9	16.7	14.33
12/13/2007	19:26	5.00	5.68	8.0	16.0	12.78

*C.2.4.1.2. Fermentor R13*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	3:05	1.00	5.38	6.4	6.5	5.69
12/14/2007	4:05	2.00	5.73	5.8	16.3	13.31
12/14/2007	6:05	4.00	5.9	6.5	16.6	13.00
12/14/2007	7:05	5.00	5.73	6.4	15.7	10.52

*C.2.4.1.3. Fermentor R14*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	15:55	1.00	5.93	4.2	15.6	12.54
12/14/2007	16:55	2.00	5.82	3.7	17.5	11.74
12/14/2007	18:55	4.00	5.61	4.5	16.4	13.18
12/14/2007	19:55	5.00	5.77	5.8	17.9	14.20

*C.2.4.2. Heat and Transfer (Sample Port TAP and TBI)*

*C.2.4.2.1. Fermentor R12*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/13/2007	20:45	TAP	0.08		8.8	16.8	14.61
12/13/2007	20:49	TAP	0.15		10.0	17.1	15.36
12/13/2007	20:55	TAP	0.25		10.0	16.3	14.23
12/13/2007	21:00	TAP	0.33		11.2	15.8	13.72
12/13/2007	20:45	TBI	0.08		8.6	16.6	13.97
12/13/2007	20:49	TBI	0.15		8.4	16.2	14.55
12/13/2007	20:55	TBI	0.25		8.8	15.9	14.54
12/13/2007	21:00	TBI	0.33		9.4	16.5	14.11

*C.2.4.2.2. Fermentor R13*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	7:48	TAP	0.05	75	7.2	17.7	13.82
12/14/2007	7:53	TAP	0.13	75	7.4	16.1	14.00
12/14/2007	7:59	TAP	0.23	75	6.5	16.7	14.63
12/14/2007	8:03	TAP	0.30	75	8.5	15.8	13.66
12/14/2007	7:48	TBI	0.05	83	7.9	16.1	14.17
12/14/2007	7:53	TBI	0.13	83	7.9	16.5	14.33
12/14/2007	7:59	TBI	0.23	83	7.8	15.8	14.01
12/14/2007	8:03	TBI	0.30	83	7.5	15.3	13.46

*C.2.4.2.3. Fermentor R14*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	20:15	TAP	0.08	75.5	7.4	15.8	13.01
12/14/2007	20:19	TAP	0.15	75.5	7.1	16.6	13.32
12/14/2007	20:22	TAP	0.20	75.6	8.1	15.8	12.99
12/14/2007	20:28	TAP	0.30	75.7	8.9	15.4	12.26
12/14/2007	20:15	TBI	0.08	84.4	6.7	15.9	12.92
12/14/2007	20:19	TBI	0.15	84.4	7.5	16.1	13.29
12/14/2007	20:22	TBI	0.20	83.9	7.1	15.8	13.06
12/14/2007	20:28	TBI	0.30	84.8	7.8	15.1	11.49

*C.2.4.3. Tank B Effluent (Sample Port MC)*

*C.2.4.3.1. Fermentor R12*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/13/2007	21:30	0.75	5.73	13.7	16.0	11.63
12/13/2007	23:00	2.25	5.56	20.6	15.8	12.45
12/14/2007	1:00	4.25	5.6	23.0	15.8	14.24
12/14/2007	2:30	5.75	5.6	25.8	14.9	12.7

*C.2.4.3.2. Fermentor R13*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	8:50	1.08	5.77	15.3	15.2	12.93
12/14/2007	10:20	2.58	5.87	20.5	15.6	13.26

*C.2.4.3.3. Fermentor R14*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	21:10	1.00	4.95	13.2	15.5	12.39
12/14/2007			4.96	16.2	15.3	12.49
12/14/2007			5	17.5	15.3	12.47
12/14/2007			4.9	19.1	15.2	11.96

*C.2.4.4. Fermentor (Sample Port Ferm)*

*C.2.4.4.1. Fermentor R12*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007		0.00	5.86	21.6	15.6	12.26
12/14/2007		0.33	5.88	21.9	15.5	12.69

*C.2.4.4.2. Fermentor R13*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/14/2007	12:40	0.00	6	20.3	15.4	
12/14/2007	13:10	0.50	5.72	20.9	15.4	

*C.2.4.4.3. Fermentor R14*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/15/2007	1:30	0.00	4.66	18.0	15.4	12.07
12/15/2007	2:00	0.50	4.74	19.5	15.5	12.68

*C.2.5. Ethanol Reactor Tower (27% dry solids)*

*C.2.5.1. Tank A (Sample Port TA)*

*C.2.5.1.1. Fermentor R15*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/15/2007	04:10	1.00	5.45	4.0	18.2	13.71
12/15/2007	05:10	2.00	5.68	3.5	26.9	16.55
12/15/2007	07:10	4.00	5.2	4.8	26.2	17.29
12/15/2007	08:10	5.00	5.6	5.0	28.3	16.05

*C.2.5.1.2. Fermentor R16*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/16/2007	2:02	0.50	5.99	3.5	19.0	14.49
12/16/2007	2:32	1.00	5.83	3.3	27.3	21.28
12/16/2007	3:02	1.50	5.78	4.3	28.3	21.18
12/16/2007	3:32	2.00	5.7	5.6	26.9	21.95

*C.2.5.2. Heat and Transfer (Sample Port TAP and TBI)*

*C.2.5.2.1. Fermentor R15*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/15/2007	11:10	TAP	0.50	74	7.3	26.2	21.08
12/15/2007	11:15	TAP	0.58	74.5	7.6	27.3	17.02
12/15/2007	11:10	TBI	0.50	80	8.3	26.4	20.80
12/15/2007	11:15	TBI	0.58	81.1	7.6	27.5	17.93

*C.2.5.2.2. Fermentor R16*

date	time	port	time (hrs)	temp (°C)	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/16/2007	5:55	TAP	0.08	74.9	7.8	26.3	22.37
12/16/2007	5:58	TAP	0.13	75	7.8	27.4	22.41
12/16/2007	6:06	TAP	0.27	75.2	8.6	26.2	22.24
12/16/2007	6:09	TAP	0.32	74.5	8.5	25.4	22.52
12/16/2007	5:55	TBI	0.08	80	8.5	26.9	21.7
12/16/2007	5:58	TBI	0.13	80	9.3	26.2	22.34
12/16/2007	6:06	TBI	0.27	80	8.0	27.0	22.56
12/16/2007	6:09	TBI	0.32	80	8.6	26.8	22.52

*C.2.5.3. Tank B Effluent (Sample Port MC)*

*C.2.5.3.1. Fermentor R15*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/15/2007			5.54	13.8	26.1	18.37
12/15/2007			5.66	15.6	26.3	18.72
12/15/2007			5.68	16.0	26.2	19.67
12/15/2007			5.7	18.1	26.3	16.65

*C.2.5.3.2. Fermentor R16*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/16/2007	6:36	0.77	5.74	11.5	26.2	19.57
12/16/2007	7:36	1.77	5.65	13.1	26.3	20.31
12/16/2007	9:06	3.27	5.15	18.5	26.5	20.19
12/16/2007	9:51	4.02	5.8	18.5	26.7	20.72

*C.2.5.4. Fermentor (Sample Port Ferm)*

*C.2.5.4.1. Fermentor R15*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/15/2007	16:00	0.00	5.57	17.0	25.9	20.31
12/15/2007	16:30	0.50	5.68	16.4	26.1	20.85

*C.2.5.4.2. Fermentor R16*

date	time	time (hrs)	pH	DE	dry solids (% w/w)	saccharification glucose concentration (% w/v)
12/16/2007	10:35	0.08	5.76	16.7	26.7	20.84
12/16/2007	11:05	0.58	5.77	16.4	26.7	18.95

C.3. Coproduct Composition

C.3.1. Wet Cake Composition

Date	Time	Run	dry solids (g/g tot)	concentration (g/g dry solids)					
				starch	protein	fat	cr. fiber	ADF	NDF
12/04/07	21:10	R1	0.286	0.0164	0.439	0.0551	0.0992	0.2437	0.3795
12/05/07	5:00	R2	0.299	0.0185	0.392		0.0958	0.2437	0.4824
12/05/07	9:00	R2	0.286	0.0324	0.431		0.0983		
12/05/07	13:00	R2	0.282	0.0168	0.412		0.0994	0.2644	0.4426
12/05/07	17:00	R3	0.309	0.0266	0.398		0.0926		
12/05/07	21:00	R3	0.278	0.0228	0.443	0.0681	0.0907	0.2705	0.4059
12/06/07	1:15	R3	0.281	0.0211	0.402		0.0955		
12/06/07	5:00	R3	0.300	0.0182	0.366		0.1089		
12/06/07	17:00	R3	0.310	0.0137	0.333	0.0662	0.1217	0.2675	0.5593
12/06/07	21:00	R4	0.287	0.0334	0.395		0.0987		
12/07/07	1:00	R4	0.296	0.0296	0.401		0.0989		
12/07/07	5:00	R4	0.296	0.0310	0.390		0.1017		
12/07/07	9:00	R5	0.304	0.0292	0.377		0.0943		
12/07/07	13:00	R5	0.303	0.0468	0.391	0.0700	0.0951		
12/07/07	16:20	R5	0.305	0.0412	0.411		0.0858		
12/07/07	21:00	R5	0.312	0.0311	0.383		0.0876		
12/08/07	5:00	R6	0.310	0.0369	0.370		0.097		
12/08/07	9:15	R6	0.307	0.0367	0.368		0.0998		
12/08/07	13:15	R6	0.292	0.0350	0.372		0.1038		
12/08/07	17:15	R6	0.306	0.0268	0.349		0.1156		
12/08/07	21:00	R6	0.319	0.0267	0.348	0.0513	0.113		
12/09/07	1:15	R6	0.403	0.0180	0.239	0.0472	0.1406		
12/10/07	9:08	R7	0.273	0.0393	0.448		0.0853		
12/10/07	13:00	R7	0.220	0.0227	0.448		0.082		
12/10/07	17:09	R7	0.153	0.0292	0.439		0.0832		
12/10/07	21:00	R8	0.315	0.0243	0.343	0.0562	0.098		
12/11/07	1:00	R8	0.320	0.0153	0.362		0.0973		
12/11/07	5:00	R8	0.290	0.0211	0.390		0.0954		
12/11/07	9:03	R8	0.237	0.0183	0.416				
12/11/07	13:06	R8	0.294	0.0204	0.416		0.0929		
12/11/07	17:00	R8	0.301	0.0294	0.388				
12/11/07	21:00	R9	0.310	0.0390	0.368	0.0557	0.1014		
12/12/07	1:00	R9	0.282	0.0407	0.358		0.1035		
12/12/07	5:00	R9	0.288	0.0376	0.402		0.0914		
12/12/07	9:00	R9	0.283	0.0311	0.400		0.0988		
12/12/07	13:13	R9	0.269	0.0288	0.416	0.0578	0.0943		
12/12/07	17:00	R9	0.341	0.0267	0.318				
12/16/07	21:00	R13	0.350	0.0415	0.329	0.0474	0.1092	0.2779	0.534
12/17/07	1:04	R13	0.341	0.0296	0.339			0.2341	0.4771
12/17/07	5:00	R14	0.349	0.0438	0.334		0.1021	0.238	0.4857
12/17/07	9:00	R14	0.353	0.0369	0.341		0.0983		
12/17/07	13:00	R14	0.351	0.0325	0.359	0.0502	0.1269	0.2419	0.4671
12/17/07	17:15	R14	0.347	0.0420	0.370		0.1007		
12/17/07	21:12	R15	0.339	0.0750	0.359		0.0933		
12/18/07	0:17	R15	0.338	0.0626	0.371		0.0934		
12/18/07	5:20	R15	0.347	0.0450	0.382	0.0532	0.0913		
12/18/07	9:05	R16	0.369	0.0997	0.290				
12/18/07	13:05	R16	0.354	0.1201	0.264		0.1048		

### C.3.2. DDG/DDGS Composition

date	time	Run	dry solids (g/g total)	concentration (g/g dry solids)			
				starch	protein	fat	crude fiber
12/05/07	9:00	R2	0.755	0.014	0.398	0.071	
12/06/07	5:00	R3	0.954	0.019	0.393	0.074	
12/06/07	17:00	R3	0.960	0.017	0.373	0.062	
12/07/07	5:00	R4	0.938	0.024	0.385	0.061	
12/08/07	5:00	R6	0.949	0.035	0.373	0.058	
12/08/07	17:15	R6	0.952	0.032	0.374	0.053	
12/11/07	5:00	R8	0.931	0.030	0.308	0.115	
12/12/07	5:00	R9	0.916	0.028	0.312	0.111	
12/12/07	17:00	R9	0.886	0.026	0.316	0.103	
12/16/07	21:00	R13	0.873	0.042	0.278		0.0907
12/17/07	5:00	R14	0.804	0.038	0.260	0.130	0.0948
12/17/07	17:15	R14	0.881	0.032	0.296	0.110	0.0946
12/18/07	0:17	R15	0.890	0.059	0.308	0.086	
12/18/07	9:05	R16	0.905	0.096	0.291	0.076	

### C.3.3. Particle Size

Date	Time	Run	mass fraction retained on Sieve No.					
			16	20	30	40	60	bottom
12/5/2007	13:00	R2	0.495	0.229	0.177	0.074	0.018	0.003
12/6/2007	5:00	R3	0.243	0.216	0.245	0.167	0.103	0.026
12/6/2007	17:00	R3	0.078	0.101	0.180	0.226	0.307	0.112
12/7/2007	5:00	R4	0.250	0.197	0.241	0.182	0.108	0.020
12/8/2007	5:00	R6	0.191	0.129	0.194	0.196	0.205	0.086
12/8/2007	17:15	R6	0.116	0.085	0.157	0.204	0.274	0.162
12/16/2007	21:00	R13	0.106	0.297	0.414	0.153	0.024	0.001
12/17/2007	5:00	R14	0.641	0.237	0.106	0.017	0.003	0.001
12/17/2007	17:15	R14	0.402	0.299	0.202	0.071	0.019	0.001

### C.3.4. Thin Stillage

date	time	run	total solids (g/g total)	total dissolved solids (g/g total)	total suspended solids (g/g total)	solid-phase protein (g/g dry susp. solids)	DP4+ (g/100 ml)
12/05/07	5:00	R2	0.0161	0.0096	0.0065	0.241	0.27
12/06/07	5:00	R3	0.0169	0.0103	0.0066	0.248	0.30
12/06/07	17:06	R3	0.0234	0.0126	0.0108	0.285	0.38
12/07/07	5:00	R4	0.0173	0.0108	0.0066	0.211	0.34
12/08/07	5:00	R6	0.0180	0.0115	0.0064	0.225	0.38
12/08/07	17:07	R6	0.0171	0.0103	0.0068	0.235	0.36
12/11/07	5:00	R8	0.0135	0.0076	0.0058		0.26
12/12/07	5:00	R9	0.0167	0.0105	0.0062	0.235	0.34
12/12/07	17:02	R9	0.0175	0.0091	0.0084	0.224	0.26
12/17/07	5:00	R14	0.0133	0.0073	0.0061	0.318	0.23
12/17/07	17:15	R14	0.0142	0.0066	0.0077		0.19
12/18/07	1:11	R15	0.0306	0.0113	0.0194	0.221	0.27
12/18/07	9:15	R16	0.0726	0.0254	0.0472	0.230	0.88



C.4. *Flour Data*  
 C.4.1. *Particle Size*

Run	mass fraction retained on Sieve No.					
	16	20	30	40	60	bottom
R1-1	0.028	0.110	0.207	0.224	0.229	0.196
R1-3	0.018	0.075	0.164	0.210	0.280	0.248
R1-5	0.007	0.025	0.112	0.483	0.263	0.105
R4-1	0.015	0.071	0.178	0.220	0.255	0.250
R5-1	0.010	0.061	0.137	0.223	0.309	0.259
R6-1	0.016	0.080	0.177	0.215	0.248	0.261
R7-1	0.009	0.048	0.129	0.203	0.281	0.328
R8-1	0.009	0.060	0.166	0.280	0.244	0.242
R9-1	0.011	0.058	0.146	0.187	0.306	0.289
R11-1	0.015	0.074	0.180	0.226	0.258	0.246
R12-1	0.016	0.081	0.194	0.244	0.271	0.191
R13-1	0.014	0.072	0.180	0.234	0.274	0.222
R14-1	0.014	0.066	0.165	0.224	0.285	0.243
R15-1	0.013	0.072	0.181	0.220	0.255	0.255
R16-1a	0.019	0.098	0.197	0.210	0.241	0.234
R16-1b	0.020	0.106	0.204	0.207	0.264	0.197