Fermentation in a Bag Measurement Method: Breathalyzer Blood Alchohol Content (BAC) Readings

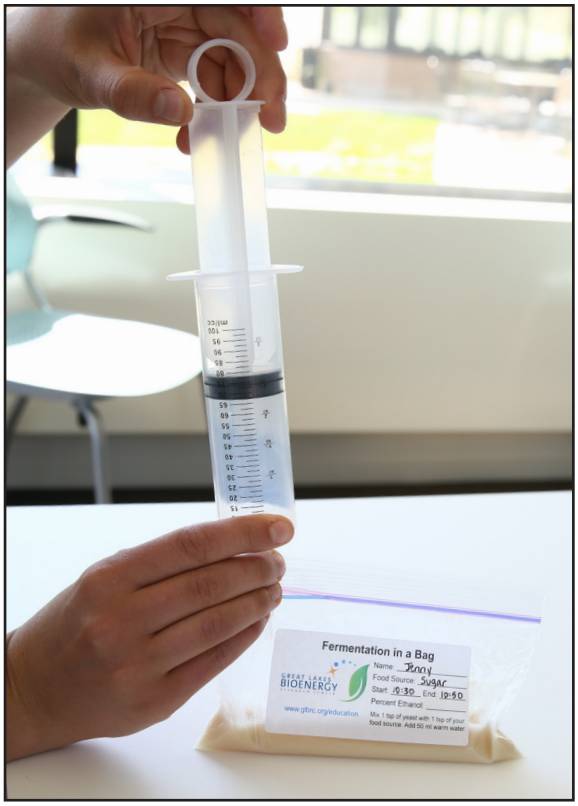
Overview

As an alternative to using an ethanol probe, students can experiment with using a breathalyzer to compare relative differences in ethanol concentrations. Breathalyzers are designed to measure blood alcohol content (BAC) in people, not fermenting bags, so the BAC reading will not tell you directly how much ethanol is in the samples. However, BAC readings can be used to (1) indicate whether some ethanol was produced and (2) make reasonable comparisons in ethanol production between different feedstocks.

In order to take a BAC measurement for an inflated bag, students extract a sample of the air in the headspace above the liquid and 'breathe' into the breathalyzer with a syringe. This method can determine the BAC of the fermentation mixture inside the bag.

Required Materials

- Breathalyzer (such as the BACtrack keychain model, ~$30 - pictured below)
- 100mL syringe (~$5)



Left: First, open a corner of the inflated bag and pull 100 mL of air from the headspace with a large syringe.
Right: Next, slowly expel the air into the breathalyzer over the course of 5 seconds. Record reading. (Pictured: BACtrack Keychain, $30)

Protocol

Follow the basic recipe and protocol for Fermentation in a Bag. After 20-30 minutes, have students open a small part of their bag and insert the syringe while being careful not to release too much air. Have students extract approximately 100 mL of air from the headspace above the fermentation mix without sucking up any liquid. Turn on the breathalyzer and follow the instrument's directions for taking a sample, substituting the syringe full of air from the fermentation bag for a 'breath.' With the BACtrack keychain model, you will need to expel the air into the device over the course of 5 seconds.

Compare each bag's BAC for different feedstocks. See sample data below for expected BAC to ethanol results. By comparing BAC to percent ethanol readings, students can collect evidence to discover the fermentation reaction equation.

Sample Data Table

The following data was collected with a BACtrack keychain breathalyzer and classroom-grade ethanol probe (such as Vernier or PASCO). Measurements were taken after 20 minutes of fermentation. Although not included in this table, initial BAC and ethanol readings were 0. The results indicate that the breathalyzer can be used to (1) detect the presence of ethanol in samples after fermentation and (2) distinguish differences between samples when multiple replicates are averaged.

Replicate	Sugar BAC	Sugar ethanol (%)	Cornmeal BAC	Cornmeal ethanol (%)	Corn stover BAC	Corn stover ethanol (%)	Sawdust BAC	Sawdust ethanol (%)
1	0.07	2.00	0.01	0.36	0.01	0.24	0.01	0.13
2	0.05	1.84	0.02	0.42	0.01	0.29	0.01	0.33
3	0.04	1.70	0.02	0.34	0.01	0.24	0.01	0.25
4	0.08	1.74	0.02	0.32	0.02	0.22	0.02	0.22
5	0.08	2.75	0.02	0.38	0.01	0.09	0.02	0.20
6	0.07	1.58	0.02	0.39	0.01	0.21	0.02	0.19
7	0.07	2.80	0.01	0.17	0.01	0.15	0.02	0.22
8	0.08	1.90	0.02	0.27	0.01	0.17	0.02	0.24
9	0.05	1.62	0.02	0.32	0.00	0.12	0.01	0.18
10	0.07	1.28	0.02	0.35	0.01	0.20	0.01	0.16
Average:	**0.066**	**1.921**	**0.018**	**0.332**	**0.010**	**0.193**	**0.015**	**0.212**
Standard error:	**0.005**	**0.155**	**0.001**	**0.022**	**0.001**	**0.019**	**0.002**	**0.017**

Sample Graph

The following scatter plot shows the relationship between final BAC readings and percent ethanol readings from that data in the table above. These results indicate that BAC is positively correlated with ethanol production as expected (R^2 = 0.86). The fitted linear regression model (% ethanol = 30 x BAC - 0.14) can be used to estimate percent ethanol from BAC readings. However, estimates should be interpreted with caution since there is quite a bit of variation in the data, especially for higher BAC readings.