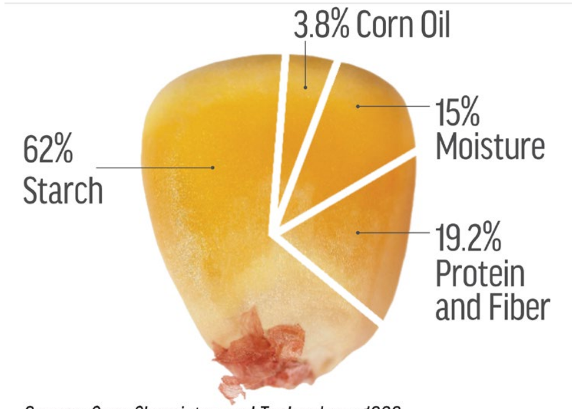
Macromolecules and fuel

Focus questions	How do the processes of fermentation and distillation alter the macromolecule content of the feedstock and fermentation products?
Vocabulary	Glucose, ethanol, coproducts, dried distillers grains



Source: Corn Chemistry and Technology, 1999

How much protein, fat, and fiber are available in dent corn for animal feed after fermentation? In this lesson, you will investigate the nutrient content in dent corn during the stages of ethanol production to construct explanations for the use of **dried distillers grains (DDGs)** as animal feed. During this process you will collect and analyze data to compare the changes that occur to the starch molecules as glucose is released and consumed by yeast to create alcohol. Will all of the glucose be consumed? What components of the dent corn are left as **coproducts?** Will yeast change the nutrient composition of the distillers grains? You will conduct additional research to obtain evidence to support/refute the data generated from this investigation, then design solutions for future uses of ethanol coproducts.

Materials

- Scale
- Weigh boat
- Corn sample - corn flour, corn meal, etc
- Distilled water
- Mortar and pestle
- Funnel
- Filter paper or coffee filters
- 10 ml graduated cylinder
- Test tubes
- Vortex
- Parafilm
- Benedict's solution
- Hot plate
- Beaker
- Lugol's iodine
- Biuret solution
- Pipette pump
- 10 ml pipettes
- Test tube holder
- Hot gloves

Procedure

Work together in groups of 2–4. Conduct the following tests on day 1, day 3 after fermentation, and again after the distillation process.

Day 1

Nutrient testing and corn mash prep of solid sample for testing before amylase:

1. Weigh out 5g of corn sample using an electronic balance. Place sample into a mortar.
2. Add 20 mL of distilled water to the food sample in the mortar. Grind sample with a pestle into a slurry.
3. Filter slurry using filter paper and funnel and collect liquid food sample into a small graduated cylinder or beaker.
4. Use the filtrate to complete the Carbohydrate Indicator Tests and the Protein Indicator Test.

Monosaccharide indicator standard test (glucose):

1. Add 2 mL of food sample solution with 2 mL of Benedict's solution in a test tube.
2. Use Vortex to give sample a quick mix (or cover with parafilm and invert test tube). Record sample color in data chart.
3. Place test tube containing food sample and Benedict's solution in a boiling water bath and heat for 2 minutes. Record sample color in data chart.
4. The glucose present in the solution reacts with the copper sulfate in the Benedict's reagent creating copper oxide, which results in an orange to red-brick precipitate. The intensity of the color depends on the concentration of glucose present in the sample.
5. Rate the precipitate color change and record sample data in the chart.
   0: no color change/negative, 1: weak/positive, 2: strong/positive, 3: very strong/positive.

Complex carbohydrate indicator standard test (starch):

6. Add 1 mL of food sample solution with 1 drop of Lugol's iodine solution in a test tube.
7. Use a Vortex to give the sample a quick mix (or cover with parafilm and invert test tube). Do not heat!
8. A bluish black color indicates a positive test for starch.
9. Rate the precipitate color change and record sample data in the chart.
   0: no color change/negative, 1: weak/positive, 2: strong/positive, 3: very strong/positive.
10. Keep the sample to observe until day 3 of the lab.

Protein indicator standard test:

11. Add 1 mL of food sample solution with 2 mL of Biuret solution in a test tube.
12. Gently mix using a Vortex (or cover with parafilm and invert test tube).
13. After 30 seconds, the filtrate solution will result in a color change to purple if proteins are present in the sample.
14. Rate the precipitate color change and record sample data in the chart.
    0: no color change/negative, 1: weak/positive, 2: strong/positive, 3: very strong/positive.

Day 3

Nutrient testing after fermentation

Perform both the carbohydrate Indicator Tests as well as the Protein Indicator Test (as completed in Day 1) on the corn mash after fermentation and again after ethanol distillation is complete. Please see the Ethanol: corn mash and distillation lesson to create the filtrates that will be necessary to finish the nutrient testing for this lab.

Table 1: Nutrient testing

Sample	Benedict's test	Starch test	Protein test
Cracked corn slurry			
Corn after fermentation			
Distillation			

Create a bar graph to demonstrate the nutrient profile change in corn as it undergoes fermentation and distillation.

Reflection

Reflect on the following questions to create an explanation below:

1. How does the nutrient profile of dent corn change as it undergoes the process of fermentation and distillation?
    a. Is all of the glucose consumed? Provide evidence to support your conclusion.

    b. How do the yeast contribute to the nutrient profile of the distillers grains after fermentation?

    c. How can the yeast contribute to the digestion of the animals consuming the distillers grains?

    d. Why are distillers grains considered to be a valuable feed for animals?

2. Provide a diagram or pie chart showing the percent change of corn composition before/after fermentation.

3. What are the current industry uses for the coproducts produced in the commercial ethanol production process?

4. Create an explanation for the current use of dent corn in commercial ethanol production and why the coproducts generated from ethanol production are used as they are. Suggest additional solutions for the use of these coproducts.

Rubric for self-assessment

Skill	Yes	No	Unsure
I generated data to construct an explanation of nutrient content change for corn as it is transformed into ethanol.			
I constructed a viable explanation for the industrial application of the remaining coproducts produced in the commercial ethanol production and suggested at least one new use.			