

Renewable Fuels



Renewable Fuels Foundation



Renewable Fuels Association



Ethanol Inputs

Unit 2 Lesson 1

Precepts

- B. Relationships
 - B2. Interact and work with others.
- E. Awareness
 - E1. Address issues important to the community.

National Standards

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- NL-ENG.K-12.4. Communication Skills.
 - NSS-EC.9-12.2. Effective Decision Making.
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Student Learning Objectives

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- As a result of this lesson, the student will ...
1. Identify what materials can be utilized to produce ethanol.
 2. Identify characteristics, advantages and disadvantages of fermentation in raw materials.
 3. Identify and recognize the factors that play an integral role in ethanol production.
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Time

Instruction time for this lesson: 50 minutes.

Tools, Equipment, Supplies

Writing surface
 Overhead projector
 Ear of corn
 Jar of soybeans
 Apple (or other type of fruit)
 Sugar Beet
 Potato
 Fast food sack
 Ethanol Product Matrix Characteristics Cards - cut from Unit 2 Lesson 1
 TM.3 / one set will be needed for each group of three students in the classroom
 AS.A - one per student
 TM.A
 TM.B
 TM.C
 TM.D
 Assess.A – one per student

Title

Unit: # Lesson: #

Key Terms

The following terms are presented in this lesson and appear in ***bold italics***:
Fermentation

INTEREST APPROACH

Place the following items in the front of the room: Ear of corn, jar of soybeans, apple or other type of fruit, sugar beet, potato, and a fast food sack. Ask students which items they think could be made into ethanol? Explain that all the items could be made into ethanol.



Look at the items in the front of the classroom. Which of these items do you think can be made into ethanol? *Allow students to answer.* Actually all of these items can be made into ethanol. Which one of these items is the best item to make ethanol from? *Allow students to answer.* The answer to that question can change. It depends upon several factors some of which might be economics and availability. Keep that question in the back of your mind as we work through what products can be used to produce ethanol, and the advantages and disadvantages of some products.

OBJECTIVE 1. Identify what materials can be utilized to produce ethanol.

*Explain to students that the production of ethanol comes from the **fermentation** process. Define **fermentation** and have the students write the definition in their notes using TM.A.*



What causes ethanol to be produced? Ethanol is produced through the science of **fermentation**. In your notebooks record the definition for **fermentation**. Use TM.A to show definition. There are many products as you have already seen that can go through the decomposition process to produce ethanol.

- I. Ethanol is a product of the **fermentation** process of a variety of raw products.
 - A. Definition of **fermentation**: A chemical decomposition which takes place in an organic substance exposed to the air, due to the action of microscopic organisms.
 - B. Ethanol production product categories
 1. Feedstock: Raw materials that are readily converted to fermented sugars.
 2. Wastes: Forest material, garbage, sewage, crop residue
 - C. Products within feedstock and wastes are classified
 1. Sugar- sugar beets, sugar cane, sweet sorghum, ripe fruits.
 2. Starch- grains, potatoes, Jerusalem artichokes
 3. Cellulose- stover, grasses
 - D. There are three principles fruits that are under investigation at this time. These include sweet sorghum, Jerusalem artichoke and fodder beets.

Continue by giving the students the two categories of materials that can be used in producing ethanol. Have the students place the items in the front of the room into the correct categories.



Those products can be placed into two categories. Those categories are feedstock and wastes. Which of the products in the front of the room would fit into each of those categories? Allow students to answer. Break down the feedstock and wastes categories farther by classifications and again have the students place the items in the front of the room into the classification categories. Have students copy down the table on TM.A to help classify the products. Conclude by mentioning the final statements on TM.A and having the students write these statements in their notes.



All the products in those two categories can be further classified into three types. Those types are sugar, starch or cellulose. How would each of the products in the front of the room be classified? Allow students to answer.

Below the definition of **fermentation** in your notes, draw the following table to help visualize how these products and a few others are classified. Use TM.A. Also, add the statement below the chart in your notes as we are going to discuss these items further as class continues. We now have the framework used to categorize and classify products used to produce ethanol.

OBJECTIVE 2. Identify characteristics, advantages and disadvantages of **fermentation** in raw materials.

Use TM.B as a key in the following activity. Have students work in groups of three to match certain products used for ethanol production with specific characteristics, advantages and disadvantages. Give each student a copy of AS.A and a set of characteristic cards that can be cut from TM.C. When student have correctly matched the products with the characteristics, display TM.B on an overhead so that it is visible to every student. Then work through the right hand columns with the students to identify advantages and disadvantages for each product.



Each of the products mentioned so far have characteristics, advantages and disadvantages associated with them. In a moment you will be given a matching challenge. On this sheet (*hold up AS.A*) you will find nine different products or groups of products that can be used to produce ethanol. You will then be given these cards (*hold up characteristic cards that have been cut from TM.C*). Your task is to match the product with the characteristics. When you are done, raise your hand and I will come over and see if you have the correct items paired together. As I pass them out I will number you off into groups of three. What questions are there? Good luck to your team.

Divide students into groups of three and pass out materials. Continue the activity until everyone has matched the product with the correct characteristic. Use TM.B as an answer key. Upon completion congratulate the students and post TM.B so that all the students can copy the information into their notes.

II. There are many characteristics, advantages and disadvantages of using different materials for the production of ethanol.

- A. Sweet sorghum
 - 1. Sorghum bicolor
 - 2. Produced in past in small production for table syrup
- B. Jerusalem artichoke
 - 1. Produces sugar in the top growth- and stores it in the roots and tubers
 - 2. Perennial so it comes back year after year.
- C. Sugar cane
 - 1. Sugar cane is only grown in four states in the United States
- D. Fodder beets
 - 1. Promising sugar crop due to its high yield.
 - 2. Crosses two beets species: Sugar beets and marigolds.
 - 3. Higher **fermentation** than sugar beets and comparable high resistance to loss of fermentable sugars during storage
- E. Sugar beets
 - 1. Rotation crop and can only be grown every fourth year.
- F. Fruit crop
 - 1. Use of grapes, apricots, peaches and pears.
 - 2. More valuable at the raw stage then converting them into ethanol.
- G. Starch crops- In starch crops, most of the 6-carbon sugar units are linked together by enzymes that break down long chains into short 6-carbon chains or pairs.

1. Two subcategories of starch crops:
 - a. Grains- corn, sorghum, wheat, barley
 - b. Tubers- potatoes, sweet potatoes
 2. Relative ease in which these products can be stored with minimal loss during production.
 3. Additional equipment needed
 4. Additional labor
 5. Additional energy costs with breaking down the chains
- H. Crop residue
1. The backbone of sugar and starch crop's- stalks, leaves
 2. Composed of mainly cellulose
 3. Cellulose must be broken down into sugar before it can be used by yeast and produced into ethanol.
 4. Breaking of cellulose bonds are more costly and complex than the breaking of starch bonds.
- I. Forage crops- forage sorghum, Sudan grass
1. Holds a promising future.
 2. Develops in an early stage of growth.
 3. More efficient because very little lignin in composition.
 4. Besides cellulose, also contains significant quantities of starch and fermentable sugars.



Congratulations on matching the products and their definitions. This is what we have just discovered. Let's copy this information in our notes. Notice on the right side there is a place to mark whether the characteristics are positive, negative or don't know. Let's take a minute and talk through the characteristics and mark some of them as advantages or disadvantages to the use of that product in making ethanol.

Work through the right hand columns with the students. Upon completion set the stage for Objective 3.



As you can see there are several positives and negatives to the products. These become factors in the decision making process as to which product is the best to use.

Objective 3. Identify and recognize the factors that play an integral role in ethanol production.

Use TM.D to guide the students through the final segment of the lesson. Lead a discussion pertaining to the information making sure the students capture the main points in their notes.



Many factors play into the decision of what product to use when producing ethanol. In your notes, add in the following factors beyond the advantages and disadvantages that your team just discovered.

III. There are many factors that play an integral role in ethanol production.

A. In choosing which crops that are made into ethanol, individuals must look at both yield and economics.

1. 1 acre of sugarcane= average of 15,000 miles

2. 1 acre of corn= 5,000 miles

B. In some cases naturally spoiled grains, vegetables and fruits at a haul-away price would be best, but not a dependable source.

C. Economy-supply and demand curve. The price of gasoline is a determining factor of whether or not to turn crops to gas.

1. Example of sugar beets: Prices are low, demand is low, and sugar refineries are closing their doors; resulting in a higher alcohol per acre yield.

D. Food for fuel is thought to be short lived. Scientists are trying to find ways to turn waste to alcohol then to fuel. However this method is more costly.

Upon completion of the discussion briefly summarize the information.



Which product should be used to produce ethanol? As you can see it depends. As a decision maker one must look at the advantages, disadvantages, yield potential, and economics just to name a few. It is not an easy decision but one that must be carefully analyzed and continually evaluated to produce the best results.

REVIEW/SUMMARY

Use a Dickens Moment to review and summarize the content from the lesson.



It is time for you to articulate your new knowledge about ethanol. You will each be given 10 minutes to write a story describing a “character” product and the process that it goes through. Maybe your character is Cornelius Corn, Sally Sugar Beet, or Sam Sugar Cane. Your story should include who the star character is and their category and classification. The advantages and disadvantages they face should come out in the story and why they were chosen to be the ethanol star. When you hear the word “author” you will work in the same teams to co-author the next great literary masterpiece. What questions are there? Author!

Allow students to prepare their stories and help them through the activity as needed. Upon completion have the students share their stories with the class.



Thank you for sharing your future best-selling stories. Today we learned about products that can be used to produce ethanol, advantages of certain products, disadvantages of certain products, and some of the factors that go into deciding what the best product to use to produce ethanol is. All of these items continue to add to your growing knowledge about ethanol.

APPLICATION

Extended classroom activity: *Facilitate a debate in the classroom based upon different products used for ethanol production. Have some students take the advantage or pro side for a product and have other students take the disadvantage or con side of a product. Allow them to debate back and forth with a moderator giving them the opportunity to further develop their understanding of the lesson.*

FFA activity: *Research and potentially begin a way to collect and transport products that could be used to produce ethanol. This may be similar to a recycling project but rather used to supply raw materials to an ethanol facility. This could be viewed as a community service project or as a fund raiser depending upon the available resources and products.*

SAE activity: *Pick a product that is used to produce ethanol that was mentioned in the lesson. Research more into the product and determine how much it would cost to provide that product to an ethanol production facility and if the income from the product would justify the decision to embark upon the endeavor. Put together draft financial paperwork to justify your recommendation.*

EVALUATION

Assess.A

Answers to Assessment:

Matching:

Sugar	Starch	Cellulose
Sugar beets Sugar cane Fruit	Potatoes Corn Barley Jerusalem artichoke	Grasses Stover

Short Answer:

1. Supply and demand, food vs. fuel debate, economy
2. Sweet sorghum, Jerusalem artichoke, fodder beets

TM.A

Fermentation: A chemical decomposition which takes place in an organic substance exposed to the air, due to the action of microscopic organisms.

Sugars

Sugar beets

Sugar cane

Sweet sorghum

Ripe fruits

Starches

Grains

Potatoes

Jerusalem artichoke

Cellulose

Stover

Grasses

Trash/waste

Being Researched: There are three principles fruits that are under investigation at this time. These include sweet sorghum, Jerusalem artichoke and fodder beets.

TM.B

Ethanol Product Matrix

Ethanol Product	Characteristics	(+)	(-)	(?)
1. Sweet Sorghum	1. Sorghum bicolor 2. Produced in past in small production for table syrup			
2. Jerusalem Artichoke	1. Produces sugar in the top growth- and stores it in the roots and tubers 2. Perennial so it comes back year after year			
3. Sugar Cane	1. Only grown in four states in the United States			
4. Fodder Beets	1. Promising sugar crop due to its high yield 2. Crosses two beets species: sugar beets and marigolds 3. Higher fermentation than sugar beets and comparable high resistance to loss of fermentable sugars during storage			
5. Sugar Beet	1. Rotation crop and can only be grown every fourth year			
6. Fruit Crop	1. Use of grapes, apricots, peaches and pears 2. More valuable at the raw stage then converting them into ethanol			

7. Starch Crop	1. Two subcategories: a. Grains- corn, sorghum, wheat, barley b. Tubers- potatoes, sweet potatoes 2. Relative ease in which these products can be stored with minimal loss during production a. Additional equipment needed b. Additional labor c. Additional energy costs with breaking down the chains			
8. Crop Residue	1. The backbone of sugar and starch crop's- stalks, leaves 2. Composed of mainly cellulose 3. Cellulose must be broken down into sugar before it can be used by yeast and produced into ethanol 4. Breaking of cellulose bonds are more costly and complex than the breaking of starch bonds			
9. Forage Crop	1. Forage sorghum, Sudan grass 2. Holds a promising future 3. Develops in an early stage of growth 4. More efficient because very little lignin in composition 5. Besides cellulose, also contains significant quantities of starch and fermentable sugars			

TM.C

Ethanol Product Matrix Characteristics Cards

Characteristics
1. Sorghum bicolor 2. Produced in past in small production for table syrup
1. Produces sugar in the top growth- and stores it in the roots and tubers 2. Perennial so it comes back year after year
1. Only grown in four states in the United States
1. Promising sugar crop due to its high yield 2. Crosses two beets species: sugar beets and marigolds 3. Higher fermentation than sugar beets and comparable high resistance to loss of fermentable sugars during storage
1. Rotation crop and can only be grown every fourth year
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1. Forage sorghum, Sudan grass 2. Holds a promising future 3. Develops in an early stage of growth 4. More efficient because very little lignin in composition 5. Besides cellulose, also contains significant quantities of starch and fermentable sugars

TM.D

There are many factors that play an integral role in ethanol production.

A. In choosing which crops that are made into ethanol, individuals must look at both yield and economics.

1. 1 acre of sugarcane= average of 15,000 miles

2. 1 acre of corn= 5,000 miles

B. In some cases naturally spoiled grains, vegetables and fruits at a haul-away price would be best, but not a dependable source.

C. Economy-supply and demand curve. The price of gasoline is a determining factor of whether or not to turn crops to gas.

1. Example of sugar beets: Prices are low, demand is low, and sugar refineries are closing their doors; resulting in a higher alcohol per acre yield.

D. Food for fuel is thought to be short lived. Scientists are trying to find ways to turn waste to alcohol then to fuel. However this method is more costly.

AS.A

Ethanol Product Matrix

Ethanol Product	Characteristics	(+)	(-)	(?)
1. Sweet Sorghum				
2. Jerusalem Artichoke				
3. Sugar Cane				
4. Fodder Beets				
5. Sugar Beet				
6. Fruit Crop				
7. Starch Crop				

Ethanol Inputs

Unit 2 Lesson1

8. Crop Residue				
9. Forage Crop				

Assess.A

A. Matching: Place each of the raw materials into the sub categories for ethanol production types.

Sugar beets
Stover
Corn

Potatoes
Sugar cane
Barley

Grasses
Fruit
Jerusalem artichoke

Sugar	Starch	Cellulose

B. Answer the following questions with short answers:

1. Name two factors that influence inputs of ethanol?

2. Name the three crops that researchers are looking for future ethanol production?