ANIMAL SCIENCE (HS)

Simulating a total mixed ration (TMR) for dairy cows

Focus question	How might we model a TMR for dairy cows using human foods?
Learning target	Students will be able to create a total mixed ration, using the proper scale, with human foods.
Vocabulary	Total mixed ration, forage, energy concentrate, lactating

HS LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS1-4	**Classroom connection:** Students will determine a TMR that results in the desired production of milk per cow, scaling the ration to create a 1lb ration using human foods.

Science and engineering practices

Using Mathematical or Computational Representations of Phenomenon	**Classroom connection:** Students use a TMR to create a scaled version using human foods. Examples of mathematical comparisons could include graphs, charts, or histograms.

Disciplinary core ideas

LS2.A Interdependent Relationships in Ecosystems	**Classroom connection:** Farms have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of space, feed, and presence of disease. Farmers maximize their space and feed while limiting disease to get the highest yields of milk from their dairy cows.

Cross-cutting concepts

Scale, Proportion, and Quantity	**Classroom connection:** Students will use math to determine a scale for creating this scaled version using human foods.

Background

In order to maintain a high level of production, **lactating** dairy cows, those actively producing milk, need a complete and balanced diet that meets their nutrient requirements for body maintenance, lactation, growth, and pregnancy. The most common way dairy farmers/nutritionists achieve this is through a **total mixed ration (TMR).** A TMR is a mixture of **forages** (e.g., hay and corn silage), concentrated feeds of protein (e.g., soybean meal and distillers grains), and additional supplements (e.g., vitamins and minerals), which is balanced to meet the specific needs of each unique dairy herd. The goal of a total mixed ration is to provide a complete and consistent diet in each bite. When done correctly, these balanced bites support the rumen environment, allowing rumen microbes to turn "trash" (feed ingredients not fit for human consumption) into "treasure" (milk and other dairy products).

On the farm, dairy herds are often split into different pens/groups based on the animal's age, stage of lactation, level of milk production, and/or stage of pregnancy. To fully optimize a TMR, nutritionists account for the differences in nutritional requirements for each of these groups. For example, a lactating cow requires increased levels of energy (carbohydrates and fats), in the form of an **energy concentrate,** and protein in order to sustain their body weight, level of milk production, and pregnancy/calf development. Non-lactating dairy cows, also known as dry cows, are not being milked daily because they are in the "rest" period of their lactation cycle, to help prepare for the birth of their calf and the start of their next lactation cycle. The diet of non-lactating cows needs to support daily activities or the last few weeks of pregnancy. The ration will maintain their body weight. They require fewer carbohydrates for energy and less protein as compared to lactating cows. Lactating dairy cows will also eat much more than dry cows, consuming 3.5–4.5% of their body weight daily, while dry cows will consume only 2–3% of their body weight. Understanding what life stage each section of the herd is in is crucial to constructing a diet that meets their requirements, allowing a herd to stay productive, healthy, and sustainable!

- Lactating dairy cows will consume 3–4% of their body weight every day. For a 1500-lb Holstein cow, that's 45–60 lbs of feed!
- A dairy cow will spend roughly 6 to 7 hours a day eating, providing the energy and nutrients to produce 6–10 gallons of milk per day. A single cow can produce nearly 200,000 glasses of milk over the course of her life.

Prior knowledge

In order to successfully complete this activity, students should know about the different macromolecules found in food: protein, fats/lipids, and carbohydrates.

They will be required to do basic algebra by finding percentage equivalents.

Materials

Check for allergies among students before using the materials below.

- Bags of pretzels *
- Bags of corn chips (not tortilla chips) *
- Bags of skittles *
- Bags of cashews *
- Bags of sunflower seeds *
- Balances that measure in ounces
- Weigh boats
- Bowls (for holding ration after measuring)

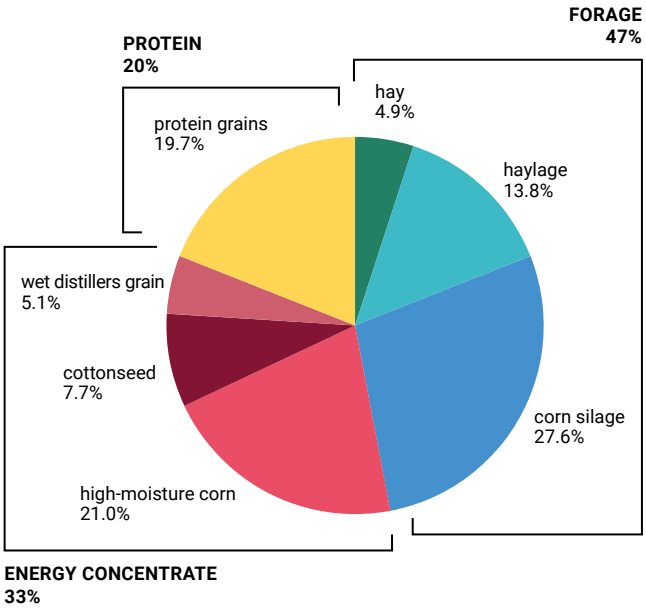
** Amounts will vary based on class and group size.*

Teacher preparation

1. Copy student sheet.
2. Prepare areas where students can measure out material and use balances. A plastic tablecloth to cover the desktop and gloves for students are recommended, since they will be measuring from a common bag and perhaps adding materials back into the bag if they get too much.
3. Students may need access to calculators in order to complete the mathematical conversions.

Procedure

1. Once students arrive, introduce the activity by asking them what they ate for breakfast this morning. If they did not eat breakfast, ask what they ate for their last meal before class. Have them share with their seat neighbor.
2. Lead a discussion about what macromolecules are in their food: carbohydrates, fats, and proteins. You may want to have some labels of common foods they might eat available for them to see the amounts of those nutrients in their food (pop tarts, breakfast cereal, oatmeal, eggs) with a list of nutrition facts.
3. Students then use the chart below and the list in the table to determine how much of each ingredient they must use to accomplish the TMR.
    - **For a 2-year old, high-producing cow, the total ration is 50 lbs/day**
    - Forage: 47%
        - Hay: 2.5 lbs or 5%
        - Haylage: 7 lbs or 14%
        - Corn silage: 14 lbs or 28%
    - Energy concentrate: 33%
        - High moisture corn: 10.64 lbs or 20%
        - Cottonseed: 3.92 lbs or 8%
        - Wet distillers grains: 2.6 lbs or 5%
    - Protein: 20%
        - Protein mix (canola, soy, etc.): 10 lbs or 20%



Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may visit a local dairy farm or compare different varieties of milk and milk alternatives (soy, oat, almond, etc) to compare nutrition labels and determine which alternatives are best.
- **Students with special needs (language/reading/auditory/visual):** Students should be able to use calculators or have support to determine the ounces that will match the percentages needed of each of the categories or could be paired with another student as partners to create the TMR. Students who may be color-blind will need to have the colors of the charts labeled for each category.
- **Extra support:** Support for students with math challenges should be provided.
- **Extensions:** Students may complete the ration formulation using a Pearson square (`pir.sa.gov.au/__data/assets/pdf_file/0009/272871/Ration_formulation_using_the_Pearson_Square.pdf`) to figure out the value of the crude protein from two different grains.

Student handout

In the table below, include your ingredient, the amount used in ounces (oz) and what percent that ingredient makes of the total ration. Note: there are 16 oz in a pound (lb).

Ingredient	% in ration	Cost per pound	Total cost of ingredient
Pretzels		$2.99 per lb	
Corn Chips		$10.18 per lb	
Skittles		$4.50 per lb	
Cashews		$9.98 per lb	
Sunflower seeds		$4.75 per lb	

Reflection

1. Why did you formulate your ration the way you did? Provide reasons for why you think this would be effective for both production of the dairy cow and profitability of the farm.

Answers will vary. Students may ask about production of milk from a high-performing herd to determine if the higher costs of certain mixes will result in higher milk production.

2. How much would your ration cost to feed per pound? To determine this, take the percentage of each ingredient and multiply it by its cost per pound. Fill in the table above.

Answers will vary depending on the percentages of each ingredient used.

3. How does your cost compare to the other groups? List costs of other groups below.

Answers will vary.

4. Do you think the cheapest group's ration is also the most profitable ration? Explain.

Answers will vary. More information is needed to make a reasoned answer.
Discuss what other information may be needed to decide.

5. Do you think your ration is the best ration? Explain.

Answers will vary. More information is needed to make a reasoned answer.
Discuss what other information may be needed to decide.

6. Explain the connection between the quality of feed in the TMR and milk production.

TMRs are a considerable factor in milk production. Lactating cows need high amounts of energy and protein to produce milk. Changes in the ingredients within the TMR will result in changes in the output and quality of milk the cow produces. Visit: **floridamilk.com/on-the-farm/farm-practices/cow-care.stml** for more information.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Determine a TMR that results in the desired production of milk per cow, scaling the ration to create a 1 lb ration using human foods.	Student created a TMR that was not properly scaled or did not follow the maximum of 5 oz rule.	Student created a TMR that was properly scaled with a variety of different ingredients.	Student created a TMR that was properly scaled with a variety of different ingredients, and was able to explain how the TMR impacts the quality/volume of milk produced.
Use a chart to show the total amount of each portion of the TMR.	Student created the TMR with amounts but did not create a pie chart.	Student created the TMR with amounts and created a chart to show the percentages.	Student created the TMR with amounts and created an appropriate graph (pie chart) to show the percentages of each and which category they were in.
Farmers maximize their space and feed while working to increase yield.	Student completed the TMR but could not explain how it maximizes the yield of milk.	Student completed the TMR and explained how it maximizes the yield of milk.	Student completed the TMR, explained how it maximizes the yield of milk, and made another suggestion(s) for how milk production might be increased.

Rubric for self-assessment

Skill	Yes	No	Unsure
I used math to determine the TMR using proper percentages.			
I used math to create a graph to show TMR components.			
I understand the relationship of proper TMR to yield of milk.			