Is there protein in those grains?

Summary (for Teachers)

When proteins are denatured and mixed with air, they can form a stable foam. In this unit, we make use of this property of proteins as a test for proteins. The unit is divided into three sections – introduction, task 1, and task 2.

In the **introduction**, the main objective is stated: We will try to use everyday processes of cooking to identify a new test for proteins. We will use this new test to decide whether an unknown (mystery) grain contains protein.

Students will divide into **six groups** of about 4-5 students. Each group is allotted a foodgrain for testing. The six suggested grains are: rice, wheat, bajra, chana dal, kala chana, toor dal.

In the **first task**, students heat their grains to ~75 °C after overnight soaking. They will observe that protein-rich foods form a light foam. However, this is a qualitative observation.

In the **second task**, students will use the water in which the foodgrains have been heated. They will shake this "foodgrain extract" in a clear plastic bottle. They will observe that protein-containing foods form a layer of foam. They will measure the layer of foam. This quantitative observation allows them to compare different foodgrains.

At the end of the second task, students will **discuss** the benefits of doing task 2 over task 1, i.e., quantitative vs qualitative observations. They will also reflect on the validity of the tests, and the need for more confirmation. The key learning is that the test yields a tentative conclusion, which is applicable for this set of grains. The test needs to include more grains and be standardised against a known test in order to be more reliable.

Type of Session (for Teachers)

This session is laboratory-intensive. Please check the materials required

Learning Objectives (for Teachers)

At the end of this unit, students will learn that:

1. When foodgrains are soaked and heated in water, their contents can release into the water
2. Heating of protein-rich grains in water leads to formation of light foam on the surface
3. Shaking of protein-containing extracts leads to foam formation
4. Formation of foam is a test for the presence of proteins
5. We can observe patterns in everyday life processes (like cooking)
6. We can systematise our qualitative observations to make them quantitative. This allows us to compare different conditions more effectively.
7. Whenever we see a new pattern, we should compare our predictions to a known test to confirm (validate) them.

Materials Required (for Teachers)

1. Food grains:
    a) White rice
    b) Wheat
    c) Bajra OR Jowar (serves as the mystery grain)
    d) Chana dal OR Moong dal
    e) Black chana OR Whole moong (choose the whole grain depending on the split grain picked in (d)
    f) Any split dal – Toor (Arhar) dal OR Udad dal OR Masur dal
2. Weighing balance or spring balance
3. 250 ml beakers or conical flasks for heating (6 – 12)
4. Measuring cylinders (100 ml capacity)
5. Electric heating plates OR Bunsen burners (with stands)
6. Scientific thermometers
7. Clear plastic bottles (~100 ml volume, 6x)
8. Deep trays that can serve as water baths
9. Strainers
10. Rulers

Time Required (for Teachers)

3 sessions of 40 mins each

Is there protein in those grains?

Introduction: Starch and Protein in Foodgrains

Question 1

Do you know any test for checking whether a food contains proteins? Please describe it here.

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> ### Note
> The expected answer here is the test of copper sulphate and sodium hydroxide (also known as the Biuret test). In the presence of protein, the solution of copper sulphate turns from blue to violet. This is covered in chapter 2 of the Class 6 NCERT Science textbook.
>
> This question is intended as revision.

Question 2

Of the foodgrains listed below, circle those which are rich in protein.

Rice Wheat Toor dal Chana dal Black chana

Question 3

In the question above, how did you decide whether to classify a foodgrain as protein-rich?

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> Here, it's expected that students will say that "they know from before" or "they know from the textbook" whether something is protein-rich. This question is deliberately asked in order to introduce the next question.

Question 4

If you were given an unknown foodgrain, how would you find out whether it is rich in protein?

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> Here, it is hoped that students will use the hint given in the first question, and state the copper sulphate and sodium hydroxide test. Teachers should allow students to come to this answer on their own, by providing hints.

In this activity, we are given a mystery grain. We will try to decide whether it is rich in protein. However, we cannot use the tests for protein which you have learnt in your science textbooks.

Let us try to find out whether there is any other way of deciding whether a food grain is rich in protein!

In this activity, we will try to use two processes that are commonly used while cooking.

We will test the foods by heating them in water.

We will test the foods by shaking the water in which they are boiled.

We shall learn whether these methods can give us reliable predictions or not.

Note

As mentioned in the summary, the learning unit tries to show whether foam formation upon shaking can be a test for proteins.
However, before we can be certain of this as a test, we must confirm its validity. The last statement in the box above is written with this in mind. It is important to impress upon the students' mind that not only will they test the foods, they will also discuss the reliability of the test.

Task 1: Heating

Question 0

When cooking food, we heat it in water. Have you ever seen any of the above foodgrains being heated? What happens to them upon heating?

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If we were to heat an unknown grain in water, do you think we could predict whether it was rich in protein? Let's find out.

1. Divide into groups. Each group is allotted a foodgrain for testing.
2. To prepare foodgrains for boiling, they will first be soaked overnight.
   a) Measure out 30 g of the grain in a beaker.
   b) Pour in some water and rinse out the grains 3 times. Drain out any spare water.
   c) Measure out 100 ml of water and add it to the grain.
   d) Soak these grains in the water overnight.
3. At the end of this period, strain out all the water from the grains into a separate beaker. Using a measuring cylinder, measure out 50 ml of this solution, and add it back to the grains.
4. Now add an additional 50 ml of fresh water to the grains.
5. Heat this beaker on a hotplate or using a burner, until the temperature reaches 75 °C. At this stage, remove the beaker and place it into a water bath, as mentioned in step 5.

6. Observe the beaker during the heating process and record any changes in table 4 below.
7. Prepare a water bath by filling a large tub with water. Place your beaker inside this bath for 10-15 minutes to cool it. NOTE: Be careful to not burn your hands while handling the beaker as it will be quite hot.
8. After cooling for 10-15 minutes, strain the water from the beaker into a measuring cylinder.
9. Be careful to not throw away the water you have strained into the measuring cylinder, as you will use it in task 3.

Note 1

Teachers may have to soak the grains in advance in order to prepare for this experiment. If they have the time, they should allow the students to measure out the grains themselves as well, so as to familiarise students with the process of mass measurement. If not, teachers may simply provide students with their respective beakers full of soaked grains, and ask them to start at step 3.

Note 2

In any case, teachers should provide students with some samples of unsoaked grains so that they can compare soaked (and later heated) grains with dry ones.

Note 3

In the above protocol, 75 °C is set as the limit because above this, rice starts to boil very rapidly, absorbing away most of the water. This will prevent us from doing foam experiments using the rice water. So you are advised to immediately cease heating as soon as the temperature reaches 75 °C.

Opportunities for learning laboratory measurement skills

The protocol offers many opportunities for learning measurement skills in the laboratory. Students can learn how to measure masses accurately and read the meniscus in the measuring cylinder while measuring volumes. We encourage you to talk about these practices with students.

Food Grain	Changes Observed
Rice	

Food Grain	Changes Observed
Wheat	
Toor Dal	
Black Chana	
Chana Dal	
Mystery Grain	

Note

In the table above, students should be encouraged to record any observations that they see fit. Observations can be about the grain, about the water in which the grains are being heated, or about phenomena on the beaker (like condensation, evaporation, and so on).

However, if an observation is made about one grain, then they should check whether that same phenomenon is also seen in other grains. This can help to make the process of observing systematic.

It is expected that students will observe the formation of foam in the case of the three dals. Foam may also be seen in the case of bajra and wheat if they have been soaked for long enough and the temperature is high.

Question 1

What are the changes to the foodgrains while they are being heated? Why do these changes occur?

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It is hoped that students will be able to identify the softening of the foodgrain upon cooking. Students can take note of which grains have softened the most, and which have softened the least. They can then check whether this pattern correlates with what they know to be high and low protein content grains.

Other possible observations include the easy removal of the seed coat in the whole grains.

The idea behind this question is to allow students to look for and describe patterns that they might see.

A slightly different, but interesting discussion that teachers can have here is to ask the students “how do you know whether the grain has changed?” In fact, in order to see the change, the students will need to see the dry grains first. Thus, we understand change by reference to some prior state.

Question 2

What are the changes to the water in which the foodgrains are heated? Why do you think these changes occur?

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> Similar to the previous question, this hopes to help students identify and describe patterns.
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> Students may notice that the colour of the water has changed, that it has become denser or more viscous. They may also notice foam formation in the water.
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> Teachers should help students reflect on why the colour and density has changed, by helping them see that materials from inside the grains (proteins, starch) may enter the water upon heating. This is an important learning from this question.

Question 3

Can you see any pattern to identify protein-rich foods? Please describe it.

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> Here it's expected that students talk about foam formation, as this is a fairly striking observation in the case of the dals. Some foam may also be seen in Bajra, if environmental conditions are suitable (temperature during soaking needs to be high). Teachers should help students think about what the origin of the foam might be.

Question 4

Based on your answer to the question above, can you predict whether the mystery grain is rich in protein? Please explain.

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> Depending on whether foam formation is seen in Bajra, students may state that it is, or is not rich in protein.
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> In some cases, very light foam formation may be seen. Some students may interpret this indicating the presence of proteins, while others may not. If such a debate occurs, the teacher should let it happen and leave it open! It is quite likely that the debate will be resolved in the next stage.
>
> At this stage, it is not necessary for the students to have the correct answer. However, they should have some justification, based on what they have seen, for their answer.

Task 2: Shaking

Question 0

Sometimes, food is whipped or shaken during the process of cooking it. Have you ever seen this happen? What happens to foods when they are whipped or shaken?

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Usually, we can only shake and whip liquids. For solid foods, if we shake water in which the food has been cooked, it can help us to see effects of shaking upon that food.

In this task, let us see if shaking and whipping can help us identify protein-rich foods.

1. Use the liquid strained out at the end of task 2 for this.
2. Measure out ___ ml of each extract. Pour this into a transparent plastic bottle and cap the bottle securely.
3. Shake the bottle containing the extract for 15 seconds.
4. Wait for another 60 seconds for any foam formed to stabilise.
5. Measure the height from the base to the top of the liquid (L) and the height from the base to the top of the foam (F) again. Record this data in table 6 below.
6. Repeat steps 4, 5, and 6 once more. Thus, you should have shaken the bottle and recorded observations twice.

7. Use the table below to calculate the thickness of the foam formed (T) as the difference in height between foam and liquid.

		Shake 1			**Shake 2**	
Sample	**Total Height, T1 (cm)**	**Liquid Height, L1 (cm)**	**Foam Height, F1 (cm)**	**Total Height, T2 (cm)**	**Liquid Height, L2 (cm)**	**Foam Height, F2 (cm)**
Rice						
Wheat						
Toor Dal						
Black Chana						
Chana Dal						
Mystery Grain						

Look at the table above and answer the questions below.

Question 1

Which foodgrain gives the most foam upon shaking?

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Question 2

Which foodgrain gives the least foam upon shaking?

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Question 3

In task 1, we tried to find a pattern that allowed us to predict whether foodgrains were rich in protein or starch.

In the table above, can you see any pattern that lets you predict whether the mystery grain is rich in protein? Please describe the pattern here, and organise the foodgrains in ascending order of protein content based on your pattern.

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> Here, students will likely use foam height as the predictor of protein content.

Question 4

Does your prediction from Task 1 for the protein in the mystery grain match that from Task 2?

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Question 5

From the point of view of making predictions about proteins, are there any benefits to carrying out task 2?

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> Question 4 and Question 5 go together. If the prediction matches, it is good. If it does not, then it's likely that the controlled shaking and quantification allow foam to be formed and protein to be identified.
>
> In Question 5, the main benefit is that it allows us to compare different foodgrains. Thus, while we know that all the dals contain protein, and task 1 (heating) allows us to see the protein foam being formed, task 2 allows us to say whether a particular dal has more protein than another. This is an important advantage.

Question 6

How can we confirm the predictions that were made about the mystery grain?

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> Teachers should allow students to think about and debate this. The straightforward, and expected answer is that we can test using the copper sulphate and sodium hydroxide test. Here, teachers can get into the question of quantification (we quantify in the case of the copper sulphate test using colorimetry – this is challenging to do).
>
> However, some students may also suggest checking the internet for information about the protein content of the grains, and seeing whether this matches the results of the test. Teachers should have a discussion on whether the information obtained from the internet is reliable, and which means of confirming (copper sulphate or internet) is better.

Some students may have heard of other tests for the presence of proteins. Teachers should allow these to be part of the discussion.

Question 7

Can we use foaming as a test for protein content in any other foodgrains? Why do you think so?

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This is the most important discussion in the learning unit. While foaming seems indicative, it has not yet been tested on other foodgrains. Teachers should discuss that until it has been comprehensively tested, the conclusions from this foaming test remain likely to be true, but cannot be trusted as much as a test like the copper sulphate test.

The key point to drive home in the two discussions is that any new pattern should be confirmed by a previously known test, in order for it to be accepted.