Curdling of Milk

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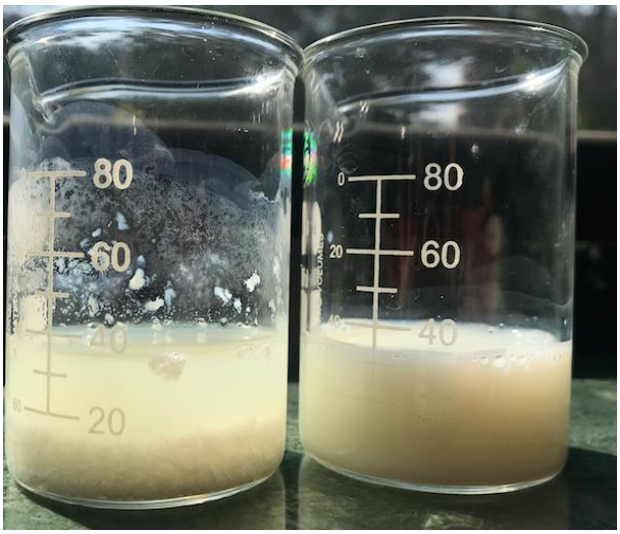
You are all familiar with the use of lemon juice to make Indian cheese known as paneer (cottage cheese, as is known outside India). The key ingredient of paneer is, of course, milk. Fresh milk is an example of a colloid, consisting of fat and protein particles floating in a water-based solution, where Casein is the main protein component of milk. The colloidal suspension scatters light, causing milk to appear white. Milk is slightly acidic. When the pH is lowered addition of another acidic ingredient allows the protein molecules to stick together or coagulate into clumps known as *curds*. The watery liquid that remains is called *whey*. The clumping reaction happens more swiftly at warmer temperatures than it does at cold temperatures.

The picture below represents fresh milk (right) and curdled milk (left). Note the sediment in the left-hand image of curdled milk.



Materials required:

Requirement	Quantity	Requirement	Quantity
Lemon		15 ml Tube	1
Milk	5g	1 ml syringe	4
1% citric acid		Measuring cylinder	1
Lemon Juice		Cutter	1
Conical Flask 250ml	1	pH paper strips	
Beaker 100ml	3	Distilled water	
Beaker 50 ml	1	Tissue paper	

Experiments to be done:

1. Cut a transverse section (TS) and a longitudinal section (LS) of the lemon supplied to you. Draw figures of the sections in the answer sheet and label the following:
   i. Exocarp
   ii. Mesocarp
   iii. Endocarp
   iv. Placenta
   v. Seeds
   vi. Oil glands
   vii. Pedicel
   viii. Remains of style
   ix. Juice sacs

   [Here it is important for the teachers to observe the cuts. A thin and uniform cut is important for the observations. At the same time teachers should also observe that the students stay safe while using the sharp objects for cutting. Many a readymade slides and images are available but the skill of cutting the slides is required for the students to get a feel of the samples.]

2. Make 100 ml of 5% milk in water. Ensure that you make a homogenous suspension (i.e. the milk particles should be completely dissolved in water).
3. Take 30 ml of milk in a 100 ml beaker. Record its pH using a pH strip, in Table 1. [It is essential that teachers observe the way students measure pH. It is very essential that the students' fingers do not touch the pH paper which is going to be dipped in the solution as this will interfere with the measurement. So the students should hold the pH paper from its very edge, then, if required, hold the whole booklet with other hand and tear of the strip. Once the piece of pH paper is in hand, the other portion of the strip which was not touched by a human hand, is to be immediately dipped into the solution. It is also to be noted that the strip is dipped and immediately taken out of the solution. The strip should not be allowed to be "soaked" in the solution]
4. Add 0.5 ml of 1% citric acid to the milk, swirl to mix, wait for 30 sec, swirl again and record the pH. Use the 1 ml syringe to add the citric acid. **Avoid a long gap between step 4 and step 5.** Follow this even in the later steps.
5. Continue with step 4 till the milk curdles as shown in the figure above.
6. Do not discard the beaker and request the invigilator to take a picture of it. [This step is useful in the examination mode and teachers can skip the process if they feel so, or keep it as a record for further teaching purposes.]
7. In a fresh beaker take 30 ml of milk. Record its pH.
8. Add 0.5 ml of lemon juice provided to you to the milk, swirl to mix, wait for 30 sec, swirl again and record the pH. Use a fresh 1 ml syringe to add lemon juice.

9. Continue with step 8 till the milk curdles to the extent it curdled in step 5.
10. Do not discard the beaker and request the invigilator to take a picture of the same.
11. Repeat steps 7 to 10 with lemon juice diluted 10 times.
12. Note the pH at which curdling of milk takes place.
    i. 1% citric acid
    ii. Lemon juice (stock Lemon juice diluted)
13. Note the total volume of the following needed for curdling of milk:
    i. 1% citric acid
    ii. Lemon juice (stock)
    iii. Lemon juice diluted
14. How many moles of citric acid are present in the total volume of 1% citric acid ($C_6H_8O_7 \cdot H_2O$) needed to curdle 30 ml of milk?
15. Considering that only citric acid present in the lemon juice was responsible for curdling of milk, how many moles of citric acid is present in 1 ml of lemon juice stock. [Teachers are encouraged to design more questions to be asked. Based on the need and local setups, questions can also be asked on the procedural aspects as well as chemistry/biology and even physics aspects of the procedures. It is also possible to collate the data from all the students, tabulate it and use that data to indicate the statistical aspects of the experimental data.]

Observation Table

Cumulative amount) of citric acid/lemon juice added (ml)	pH recorded		
	1% citric acid	Stock lemon juice	10 times diluted lemon juice
0.0			
0.5			
