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Science
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Milk

Introduction

Cows' milk is a mixture that consists of about 88% water, 4-5% butterfat and 7% milk solids. This varies somewhat among breeds of cows. Some cows are bred to produce more butterfat and some for higher milk production. Three of the most notable components of milk are casein, whey, and lactose. Casein and whey are proteins while lactose is a carbohydrate. The enzyme lactase is produced in humans and other mammals to break down the lactose, which your body can digest for energy. Some people are lactose-intolerant which means their body doesn't produce lactase to help them digest the lactose. Some people are allergic to casein while other people are allergic to whey. (1) There are different types of casein and whey proteins. Most mammals produce 3-4 different casein protein types. The two major whey proteins are beta lactoglobulin and alpha-lactalbumin. (2)

Human milk is quite different from cows milk, especially in its content of oligosaccharides…short chains of about 3-10 monosaccharides. Using a chemical analysis method called mass spectrometry, scientists have recently been able to categorize the various oligosaccharides in human milk. Oligosaccharides specific to human milk (HMO's…human milk oligosaccharides) have been found to support the growth of beneficial bacteria in the intestines of infants and are important to a properly functioning immune system. (2),(3) Until recently, human milk was poorly understood and recent research has shown numerous advantages of breast feeding babies over mass-produced baby formulas. (3),(4)

Most companies pasteurize their milk to kill most of the bacteria that may transmit diseases to anyone who drinks the milk. Pasteurization consists of heating the milk at temperatures of at least 145^{o}F for thirty minutes or flash pasteurization, which is at a higher temperature for less time. Another process that most milk goes through is called centrifugation. Centrifugation is done to decrease the amount of fat in milk. Centrifugation spins the milk at high speeds and the watery skim of the milk moves to the outer edge and the less dense fat stays in the middle. Milk can also be homogenized, in milk the less dense fat will float to the surface

as curds or cream; homogenization is breaking up the fat particles into tiny pieces so that it will not separate from the milk keeping it as an emulsion.

Milk can be made into many other products such as butter, which is made by churning milk, causing the butter fat to separate from the water, or buttermilk. The butterfat is then kneaded removing more buttermilk and creating butter. Using machinery, butter can go through this entire process in seconds. Butter consists of 82% fat, 16% water and 2% milk solids. There are also cultured milk products, which include sour cream, buttermilk, cheese and yogurt. Cultured milk products differ from un-cultured milk products in that to make cultured milk product bacteria are employed to convert the unprocessed milk into something different.

Milk is a mix of polar and non-polar substances. Most of the chemical components of milk are polar. This results in milk acting primarily like a polar liquid. A polar substance, means that it's charges are unbalanced, so it has more positive or more negative charges at one end of some of its molecules. Grease and oils are examples of non-polar substances that have no charge inbalance. Water is a polar substance so it is at an imbalance of it's electrons also. The oxygen in water (H_2O) steals negatively charged electrons from the hydrogens, giving the oxygen a negative charge and giving the hydrogens a positive charge. Since Milk is mostly water it is largely a polar substance.

In this quick experiment, we will use 2% milk and a dye to illustrate some of the properties of milk that are caused by the water and the other chemicals in milk...fats and proteins.

Materials and Methods

Materials:

- 2% milk
- Food coloring
- A toothpick
- Soap
- A petri dish

Methods:

First we filled the specimen dish with 2% milk, and then we put a drop of food coloring into the center of the dish of milk by holding the dye bottle just above the surface of the milk. Then we put the tip of a clean toothpick into the milk about a centimeter away from the colored dye. We waited for about a minute to observe any changes. We removed the toothpick and dipped the dry end of the toothpick into the soap and put that end into the milk. We observed for at least a minute and recorded any changes.

Results

When we put the dry end of the toothpick into the milk no reaction or change in the dye or the milk occurred. When we put the soapy end of the toothpick into the milk, the dye shot across the surface. After a short while a swirling of the milk made a wave-like pattern with the dye. Then when we took the toothpick out the swirling pattern continued for a bout 30 seconds (figure 1).

Figure 1

Discussion

The reason nothing appeared to happen with the dry toothpick is because nothing was introduced to the liquid. Then when soap was put on the toothpick something was introduced to liquid causing a reaction. This is because soap is a non-polar substance and milk is a polar substance. The soap disrupted the surface tension of the milk and so dye which operated just as an indicator of movement on the surface quickly moved to the periphery of the dish. Detergent or soap molecules have a charged head section and non-charged tail section, so the way detergent works is that the tail part attracts grease and scum, while the head attracts water (figure 2). As the micelle of detergent forms the grease gets trapped inside the micelle. A micelle forms with the water-loving heads oriented towards the water and the water-hating tails oriented away from the water. When molecules of soap, which have both hydrophilic and hydrophobic parts to their structure, are put in a polar substance like water or milk they form micelles.(figure 3). This constant forming of micelles most likely causes the swirling. The hydrophobic tails shown as wavy lines in the figures below, avoid the water associating together in the interior of the micelle. The hydrophilic heads shown in the figures as round balls are oriented towards the water. This experiment uses a control group system meaning that the two toothpick immersions are exactly the same except for one variable, the soap.

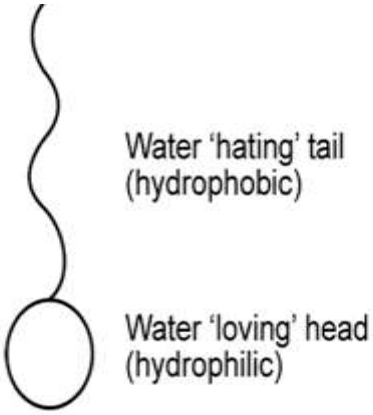

Figure 2

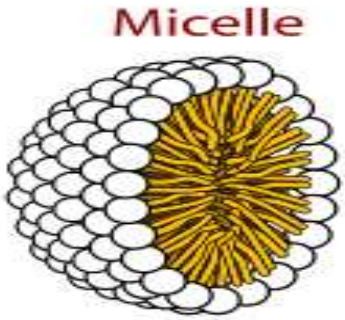

Figure 3

1) http://ansci.illinois.edu/static/ansc438/Milkcompsynth/milkcomp_protein.html

2) How glycan metabolism shapes the human gut microbiota; Nature reviews Microbiology 2012

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http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4005082/

3) http://ffhi.ucdavis.edu/prog/fg/proj/mo

4) Nature's first Functional Food, Science August 15 2014, pg 747