Determination of Terminal Velocity to Test Purity of Milk

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Abstract :- In recent year the use of milk and milk product has increased because milk is very important human nutrient. As far as the purity of milk is concerned, adulteration of milk is one of the major issue because some other substances often mixed with it which makes the milk impure. To maintain and control the process and quality of milk products measurement of purity of milk is essential. The aim of this paper is to determine the purity of milk with the help of measuring density of milk in terms of terminal velocity.

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I.   Introduction

For any human being Milk and Milk products are necessary in the daily use because they are very important human nutrients. To maintain process of milk and also to control quality of the milk product, it is essential to measure the purity of milk[1,2]. Milk and its products are good source of calcium. From very ancient times milk has been known to be a complier food. Usually, milk obtained from cows, goats, buffaloes, sheep etc is drunk by human beings. The main products of the milk are butter, curd, buttermilk, cheese etc.

In these days adulteration in milk is one of the main problem in terms of purity because other substances are very often mixed with it, making the milk impure which ultimately causes serious health problems.

Adulteration in milk can be done at home using (i) Reduction Test : Boil milk on slow heat for 2-3 hours till it solidifies and become hard. (ii) Starch in milk (iii) Test for urea in milk (iv) Formalin in milk (v) Dalda / Vanaspati in milk (vi) Water in milk (vii) checking for synthetic milk

Milk testing and quality control is an essential component of any small, medium or large scale milk processing industry .

The aim of the present work is to determine the purity of milk by measuring density of milk in terms of identifying the terminal velocity. Here we have used Method 6 (water in Milk) as listed above to identify the purity of milk.

II.   Milk Structure & Composition

Milk is very complex food. More than 1,00,000 various molecular species of milk has been found. There are number of factors that can affect quality as well as composition of milk which are variations in breed, cow and herd including feed considerations, seasonal and geographic variations etc.

For the young mammalian, the role of milk in nature is to nourish and provide immunological protection. Cow, buffalo, sheep, goat and Yak are the main food source and milk producing animals. The nutritional value of milk [3,4] is very important. It contains all the nutritional elements like sugar, proteins, fats, vitamins, minerals, salts and water needed for any human being. Cow's milk contains about 87.2%water, 3.7%Fats, 3.5%proteins, 4.9%sugar as well as many vitamins (vitamin A, C, D & others) and Minerals(Ca,Mg,K,Na etc). The composition of milk can be approximately given as under :

* Water : 87.3% (Range : 85.5% to 88.7%)

* SNF (Solids Not Fat) : 8.8% (Range ; 7.9 to 10.0 %)

This includes,

- Lactose : 4.6 % ,
- Acid Products : 0.18 % (Citrate, Acetate, Lactate, Formate, Oxalate)
- Protein : 3.25% (3/4 Casein)
- Minerals 0.65 % (Ca, P, Citrate, Mg, K, Na, Zn, Cl, Fe, Cu, Sulfate, Bicarbonate)
- Enzymes : Peroxidase, Phosphatase, Lipase, Catalase
- Vitamins: A, C, D, Riboflavin, Thiamine etc.

III. Chemical and Physical Structure of Milk

Knowledge of this physical and Chemical structure of milk helps to understand working of milk coagulation. The general diagram of milk structure is as shown in Fig.1.
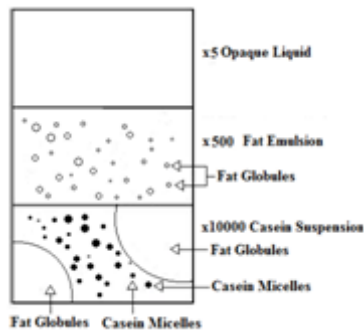
Fig.1 Milk Structure

Milk is colloid of butterfat globules or an emulsion in a water- based (aqueous) fluid[5]. Each fat globule is surrounded by a membrane consisting of proteins and phospholipids. The fat globules do not coalesce and forms a separate layer because of protection by a membrane layer which keeps the fat particles separate from the water phase. These emulsifiers keep the individual globules from joining together into noticeable grains of butterfat and also helps to protect the globules from the fat-digesting activity of enzymes found in fluid portion of the milk. Vitamins A,D,E and K which are fat soluble are found within the milk fat portion.

The largest structures in the fluid portion of the milk are casein protein micelles: Aggregates of several thousands of protein molecules,bonded with the help of very tiny particles of calcium phosphate (<300 nm scale). Each micelle is almost spherical in shape and is about a tenth of micrometer across. The main group of milk proteins is caseins.Four different types of casein proteins are found and by weight they collectively make up about 80% of the protein in milk. The Caseins are not soluble in water. Most of the casein proteins are bound in to the micelles. Its important feature is that its outermost layer consists of strands of one type of protein, kappa-casein, reaching out from the body of the micelle into the surrounding fluid. These all kappa-casein molecules have a negative electrical charge and therefore repel each other, thus keeping the micelles separated under normal conditions and in a stable colloidal suspension in the water-based surrounding fluid.

When milk is examined using a microscope,

(i) At low magnification (5X or less), a uniform but turbid liquid is observed.
(ii) At relatively higher magnification (500X), spherical droplets of Fat, known as fat globules can be seen.
(iii) At even much higher magnification (more than 10,000X) the casein micelles can be observed as shown in Fig.1.

IV. Concept of Terminal Velocity

Any fluid has its own viscous force. This force opposes the motion of a body when it is falled through a fluid under gravity. Stoke's law states that the magnitude of this force for a body falling under gravity is directly proportional to the velocity of the body in the viscous medium[6]. The acceleration of falling body due to the gravity increases the opposing viscous force. When the up thrust and the opposing force due to the viscosity are equal to the downward force due to gravity, the body falls with a constant velocity ,called terminal velocity.

The fluid resistance increases as a falling object accelerates downward due to gravity. The drag force produced equals the downward force at a particular speed, mostly the weight, mg of the object. Eventually, it attains a constant speed. Teraminal velocity changes directly with the ratio of drag to the weight of the body .i.e. Increased weight gives higher terminal velocity while higher drag means a lower terminal velocity.

Terminal velocity can be represented by $V_t = (2mg / \rho AC)^{1/2}$ where,
* V_t : Terminal velocity
* m: Mass of the falling object
* g: Acceleration due to the gravity
* c: Drag coefficient
* ρ: Density of the fluid through which object is falling
* A: Projected area of the object.

Thus, terminal Velocity of an object changes due to the properties of the fluid, mass and the cross sectional area of the object.

By noting the time for the given body to fall through a known distance, terminal velocity can be determined. Here, it depends on the density of milk. Terminal velocity changes when milk drops are made to fall through a viscous medium which depends on the concentration of milk. In the present study pure coconut oil is used as the viscous medium.

V. .Experimental :

V.1 Preparation of Milk Solution:

The working standard solutions of milk were prepared by diluting pure Buffalo milk in 10%, 20%,….distill water. All glassware was initially washed with detergent and then rinsed several times with deionized water and then dried.

V.2 The Experimental Set up :

The experimental set up is as shown in Figure 2. Long glass pipette tube (about 100 cm length) is used which is filled with oil. Markings are made at predetermined distances (top and bottom)on the tube i.e 'd' is fixed which is about 50 cm. A drops of milk is poured into the funnel and is allowed to fall into the tube. Stopwatch is started

when the milk drop crosses the upper(top) mark. The stopwatch is stopped when milk drop crosses the bottom(lower) mark. Time 't' taken for the drop to move the distance 'd' between the top and bottom marking is noted. Number of trial is made and then terminal velocity is calculated using equation $V = d/t$.

Fig.2 Experimental Set up

The same process is repeated by taking milk of different dilutions. Thus terminal velocity is calculated for each different solutions.

VI. Results and Discussion :

The observed results are tabulated as shown in Table1.

Table .1 Terminal velocity at various percentage of milk

Trial	% of Milk	Time t(sec)	Terminal Velocity (m/sec)	Mean v (m/sec)
1	100	2.53	0.198	0.1973
		2.54	0.197	
		2.53	0.198	
		2.55	0.196	
2	80	2.95	0.169	0.1692
		2.96	0.1689	
		2.95	0.169	
		2.94	0.17	
3	60	3.1	0.161	0.1602
		3.12	0.16	
		3.13	0.1597	
		3.12	0.16	
4	40	3.35	0.149	0.1497
		3.33	0.15	
		3.33	0.15	
		3.34	0.1497	
5	20	3.5	0.143	0.1425
		3.51	0.1424	
		3.51	0.1424	
		3.52	0.142	
6	0	4.19	0.1193	0.1192
		4.19	0.1193	
		4.2	0.119	
		4.2	0.119	

Distance between Top and Bottom marking, d=50 cm

Figure 3 shows the graphical relationship between Terminal velocity and different dilution percentage of milk.
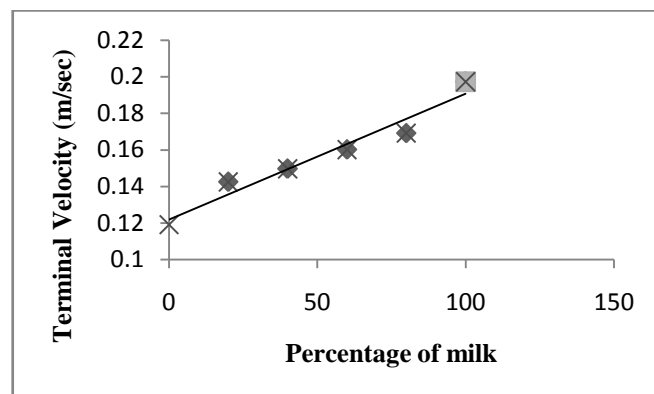

Fig.3 Variation of terminal velocity with percentage of milk

It is observed that terminal velocity is less for less concentration of milk where as for pure milk it is high i.e terminal velocity decreases with the concentration of milk. For pure water it is minimum. Hence, with the increased density of milk, terminal velocity increases.

VII. Conclusion

Terminal velocity of a body falling through a fluid under gravity depends on the density of the body. As the density of Pure milk is higher than that of one diluted with water, terminal velocity of a body falling through milk decreases with its density. It is found that terminal velocity decreases with the concentration of milk. For pure water it is minimum. Hence, terminal velocity increases with the density of milk.

References

[1] Marshall,R.T.,Standard methods for the determination of dairy products.16th ed. publ. American Public Health Association (1992).

[2] J.C.Upadhyay, Properties of Matter

[3] Cashmen K.D., Encyclopedia of Dairy Sciences, Academic Press,London (2003)

[4] R.K.Gaur, Engineering Physics

[5] Manual of Methods of Analysis of Foods (Milk and Milk Products), Directorate of general Health Services, Government of India ,New Delhi, 2005.

[6] Terminal Velocity by Blanche Mc Cray Boyd.