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Inexpensive Piezoelectricity-Based Milk Adulteration Detection to Validate Consumption and Distribution Hygiene

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Abstract:- Milk is a commodity which is perishable. Especially in the summer season, it gets spoilt very quickly. Hence to maintain the freshness, venders ploy by using preservatives, water to increase the volume of milk, but to counter the reduced density, they use thickening agents and detergents. This increase the cosmic nature of milk. This notion of mixing water with milk is persistent in poor households where they cannot afford to buy or get milk in a larger quantity. The increased quantity is directly reflected by the increased profits. Adding water will not affect the color of the milk, therefore, it is impossible to detect with direct visibility. Although this adulteration will reciprocate in form of loss of essential fats and proteins. It may also result in menstrual problems for women. Hence the study and exploration of methods to control this adulteration is vital. A low-cost, easy -to-use device is proposed that leverages piezoelectricity combined with liquid density and viscosity to detect any adulteration of the milk towards consumption and distribution hygiene.

Keywords:- *Piezoelectric, Pasteurisation, Viscosity, Density, Milk-Chilling.*

I. INTRODUCTION

We live in a fast-paced world. Everyone is so involved in the routines that they don't even have time to consume basic macronutrients like proteins, essential fats, calcium, carbohydrates, etc. Because of this, milk becomes an important staple of the diet. Milk is a nutrient-rich, white liquid food we which have been consuming since as early as 7000 BC. Because the infants do not consume food that is difficult to digest, milk becomes their primary source of nutrition. Milk, also called as dairy milk, because it is extracted from farm animals. We boil this milk to eliminate microorganisms and harmful pathogens. This process of boiling of milk is called pasteurization, which makes it edible either in its pure form or in the form of dairy products.

In rural India, milk is delivered door to door, daily, by the milkmen carrying bulk quantities in cylindrical metal containers. The current milk chain flow in India starts with the milk producer, who gives it to the milk collection agent every day. The milk which is collected is then taken to a "milk-chilling" center and it is transported to the processing plant, then to the sales agent and finally reaching the consumer.

A 2011 survey by the Food Safety and Standards Authority of India has found that nearly 70% of the samples had not conformed to the standards required for milk. In the survey, it was found that 8% of the milk samples contained detergent in it which is perilous to health. Around 10% of samples were found to have excessive quantities of water added to them[1]. This is done by the vendor to increase the quantity of milk and thereby increase profits [2].Milk is collected by locals without any aseptic conditions and i.e. with bare hands, questioning their sanitary habits, which introduces the question to hygiene. Many cattle owners fail to provide proper hygienic environment to their cattle which then leaves them exposed to multitude health hazards. For example the unsanitary nature of cattle sheds along with the milking yards, actively contributes to the rise in cases of mastitis conditions. This unhygienic milk production leads to a deteriorating storing quality and spoilage of milk and other dairy products. Without any safety measures taken, the milk might inhabit an infinite number of bacteria which multiply exponentially and thus making the milk impure. This milk when carried and added to the central milk station will challenge the quality of the total volume of milk. Thus making the milk unfit to consume. Hence the first precautionary step needs to be adopted to check the quality of the milk. It should be based on various parameters which will help decide whether the milk is pure and ready to be consumed.

High-end milk quality testing machines and equipment are not affordable to locals, refraining them from knowing the milk condition when received. Hence each household must have a quality tester which is inexpensive and provides results with accuracy. This paper provides insight into an alternative and inexpensive milk quality tester which uses state of the art technology to test the milk based on different parameters and thus ensure that the milk which is given to the central milk station is pure and is further ready to be processed to make it fit for consumption. Therefore to overcome these problems we have come up with an inexpensive device that will quickly calculate the viscosity and density of milk. This will give consumers a clear idea about how much water is added to milk.

II. PROPOSED SYSTEM

A quick and inexpensive mechanical method can be adapted to check the overall quality of milk. This system will be primarily based on a falling marble experiment. In this method, we take a predetermined quantity of sample milk collected from local milk producer units.

A cylindrical container will be employed to conduct the experiment. The system will employ piezo or load cells to generate a voltage. Depending on the force with which the marble falls on the piezoelectric cells, an equivalent voltage gets generated. This voltage will then be used to determine the density and viscosity of the given sample milk.

To begin with, the experiment a pilot study is done, before implementing it to the real world. [3] Viscosity measures the flow of a liquid substance. the viscosity of a dense liquid is high (honey) and that of a less dense liquid is low (water). The formula to calculate viscosity can be stated as

$$\rho = [2(ps - pl)ga^2]/9v \tag{1}$$

Here, for the experiment to be conducted p_s can be stated as the density of the sphere, $p_l$as the density of the liquid, g is acceleration due to gravity, a is the radius of the sphere, and v is the velocity of the sphere. We start our experiment by calculating the density of the sphere. To calculate the density of the sphere the formula of density can be stated as

$$d = m/v \tag{2}$$

Now for the density, we first need the mass (m) and volume (v) of the sphere. Place the sphere on a weighing machine to calculate the mass of the sphere. The volume of the sphere can be calculated from the formula

$$V = (4/3)\pi r^3 \tag{3}$$

Now after knowing the mass and volume we now have the density of the sphere. the next step is to calculate the density of milk. To calculate the density of milk we first need the mass and volume of the milk sample. To calculate the mass, first calculate the mass of the graduated cylinder by placing it on the weighing machine and then fill the graduated cylinder with the milk sample, now again place the cylinder on the weighing machine and note the mass. Now finally subtract the mass of the graduated cylinder from the collective mass of milk sample and cylinder. We now have the mass of the milk in the cylinder. now for volume by reading the scale on the graduated cylinder note down the volume of the milk. Now finally use the formula for density and calculate it. We now need to calculate the velocity of the sphere. to calculate this, mark one inch below the maximum volume reading and mark one inch above the lowest level. Place the sphere inside the cylinder and make sure that the bottom of the sphere and the mark coincides. This is the starting point of the sphere. keep a stopwatch at the side. When you release the sphere start the timer and stop it when it reaches the bottom mark. As shown in fig. 1 the reading of the graduated cylinder between the two marks gives us the distance and the stopwatch gives the time reading. Now the formula for velocity is

$$v = d/t \tag{4}$$

Substitute the value and we get the velocity of the sphere. Now the value of g is 9.8 m/s^2. substitute all these values and we get the viscosity of the milk sample[6].

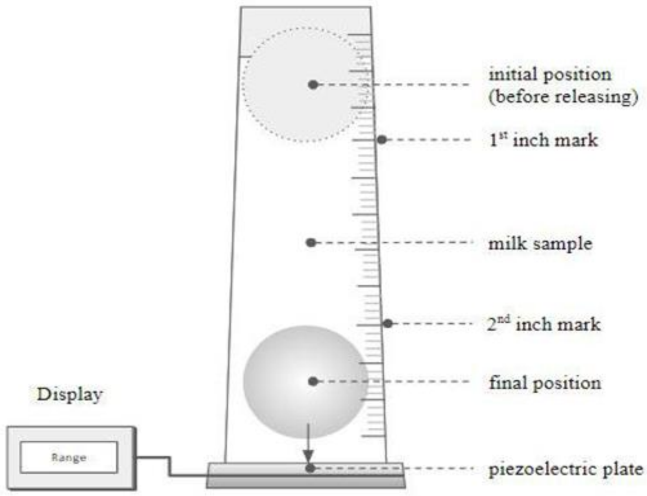

Fig 1:- Arrangement of the proposed apparatus

When the ball hits the piezoelectric plate beneath the cylinder a small voltage is generated, this voltage differs for different types of liquids. The voltage depends on the speed with which the ball strikes the plate. If the speed of the ball is high a greater voltage will be generated which indicates that the viscosity of the milk is low and vice versa. Hence from the above experiments performed a highly accurate reading can be obtained and then passed to the vendors and consumers. Now to test the milk quality the consumers and vendors just need to drop the ball and observe the readings instead of performing the above steps again and again which is arduous. Then the values obtained can be compared with the standard readings and thequality of milk can be determined.

III. METHODOLOGY

The flowchart in fig. 2 represents the schematic of the milk testing procedure. A predetermined quantity of milk sample is taken into account and then tested using the falling marble experiment or known as the piezoelectric test. The outcome of this test will be a range of voltage along with the viscosity and density readings for different milk samples. This standardised range of the values is now passed on the vendors and consumers.the vendors and consumers now just need to drop the sphere inside the cylinder consisting of the milk sample, instead of conducting the whole experiment. The vendors and consumers can now match their readings with the standardised range chart and can identify the amount of water added if any.

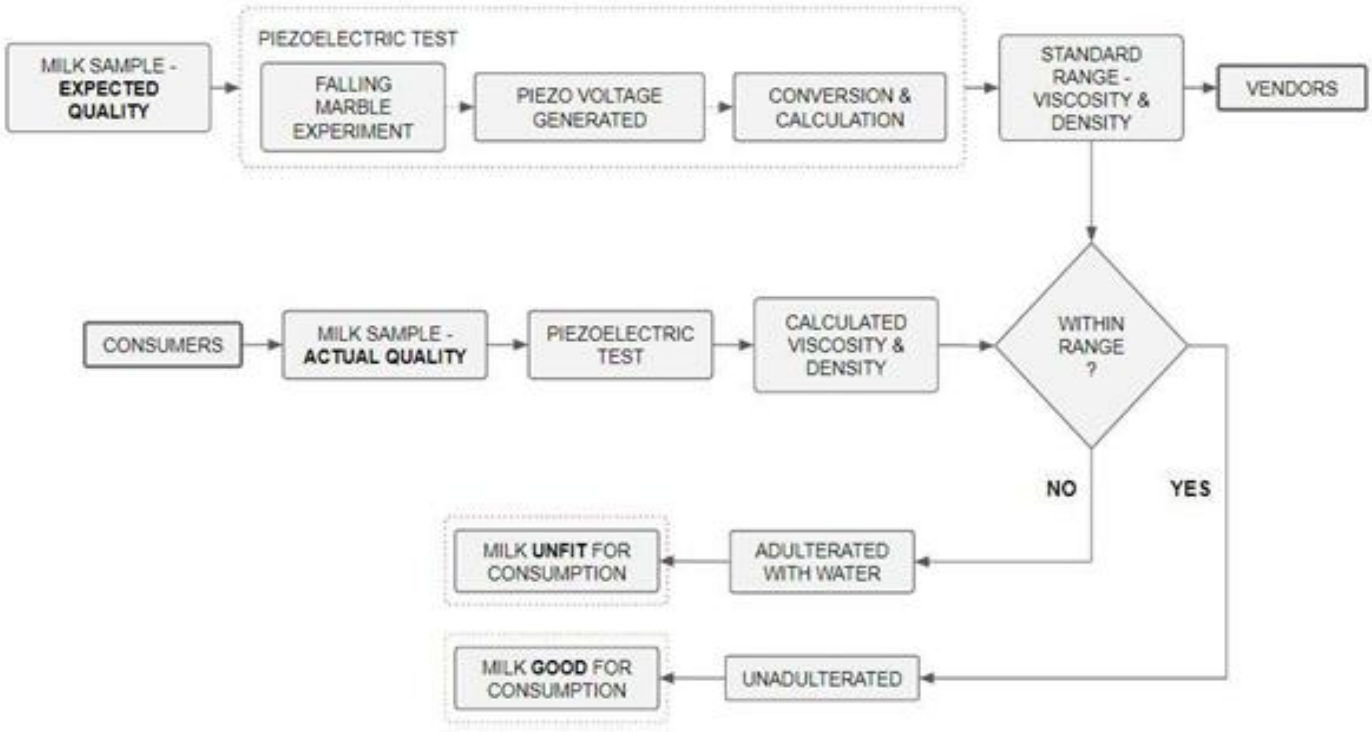

Fig 2:- Flowchart of proposed methodology

IV. CONCLUSION

As seen from the results above, the variations in different properties of milk depend upon the quantity of water added to milk. This inexpensive device can be used to find the water levels in milk. The scope of this project is very broad as various elements can be adjusted with this device to detect various contaminants in milk. Without actually investing in expensive products that calculate the viscosity of milk, this device can be used to provide an approximate result. This can be used by the vendor to check the quality of milk they receive from farms or in every household to check the quality of milk they receive from vendors.

Although the current scale of adverse effects of the addition of water to milk cannot be fully understood, the likelihood of milk and dairy products contaminated with water cannot be ignored.

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