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Development of an Experimental Setup for Detecting Extent of Urea Adulteration in Cow Milk using Polytetrafluoroethylene

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Abstract- *Adulteration of food is a global concern. Due to lack of stringent measures, many consumers are at risk of contracting diseases. Hence, there is a need for a method which would detect the adulteration of food and also quantify the degree of adulteration.Cow Milk is one of the most commonly used household products in India. It is a daily requirement in almost all houses. Adulteration of milk is done by adding harmful chemicals in milk to increase its quantity for economic purposes. Urea is a common adulterant in milk which, when added to a certain extent, has damaging effects on the human body. These can be hearing impairments, cancer, heart problems, and can even be fatal in some cases.his paper proposes a method to detect the amount of urea added in milk using Polytetrafluoroethylene (PTFE).*

Keywords- *Adulteration; Urea; Urease; Thermocouple; PTFE.*

I. INTRODUCTION

Adulteration of food is a global concern. It is done by removing or adding substances to food to alter its appearance or to increase the quantity. Adulteration of milk has been a common concern for some time now. Milk is the second most likely food product to be at the risk of adulteration after olive oil 1 [1]. Common adulterants in milk include urea, starch, formalin, detergents, hydrogen, melamine and boric acid. These adulterants pose a health hazard to the consumers. The composition of milk is shown in Table 1 [8].

Table 1. Composition of Milk

Component	Percentage Composition
Water	87.8
Carbohydrates	4.8
Fatty Acids	3.6
Protein	3.2
Urea	0.14
Calcium	0.12
Cholesterol	0.014

The parameters used to estimate the quality of milk are freezing point, Solid-Not-Fat percent (SNF), protein content and percentage of fat. The adulterants are added to milk to alter these parameters, thus decreasing the quality of milk.Urea is naturally found in milk. The maximum limit of urea in milk is 70mg/100ml set by the PFA (Prevention of Food Adulteration) Rules and FSSAI (Food Safety and Standards Authority of India) Act 2006 [2]. The added urea in milk is detrimental to the human body. In a recent study on the extent of milk adulteration conducted in Varanasi, India the extent of adulteration of urea was found to be 60% [15]. Hence, adulteration of urea in milk is a pressing concern.The presence of urea overburdens the kidneys as they have to filter out more urea content from the body [9]. Also, Bacterial ureases play a role in disease pathogenesis. They are connected with urinary stones occurrence and catheters blocking, pyelonephritis, ammonia encephalopathy, hepatic coma as well as gastritis. [11]Thus, it is crucial that milk should be tested for the amount of urea. This paper suggests a method to detect added urea in milk using Polytetrafluoroethylene (PTFE) temperature sensing method.

II. BACKGROUND

Urea, a diamide of carbonic acid, is an organic compound present in milk. Urea has the chemical formula $CO(NH_2)_2$.
It is a commonly found adulterant found in milk. The concentration of urea in milk is around 70 mg/100 ml. It is added to milk to increase the Solid–Not-Fat percentage [10].

A. Hydrolysis of Urea by Urease.

Urease, a naturally occurring enzyme, found in many organisms is used as a catalyst in the hydrolysis of urea into carbon dioxide and ammonia. Thus, when urease is added to the vessel containing urea, it undergoes hydrolysis to release

ammonia and carbon dioxide. Urease and ammonia, generated during urea hydrolysis, may be toxic to human tissue [12] and probably have a role in long-lasting diseases, like atherosclerosis or rheumatoid arthritis [13, 14].

Figure 1: Hydrolysis of Urea Equation

B. Action of Ammonia ions on Polytetrafluoroethylene.

In general, PTFE polymers are chemically inert. However, under certain circumstances, few chemicals such as ammonia (NH_3), Amines and metal hydrides react with PTFE. Also, electrons in liquid ammonia can alter PTFE. Thus, ammonia is one of the chemicals which reacts with Polytetrafluoroethylene.

The hydrolysis of urea in the presence of urease produces carbon dioxide and ammonia [Fig. 1]. The ammonia ions produced react with the PTFE tape which is wound on the thermocouple. The property of PTFE is such that it attracts ammonia toward it [6]. This leads to an increase in the temperature of the Polytetrafluoroethylene tape which is sensed by the thermocouple.

III. EXPERIMENTAL SETUP

The setup consists of milk vessel, thermocouple, PTFE tape and a digital multimeter [Fig. 2].

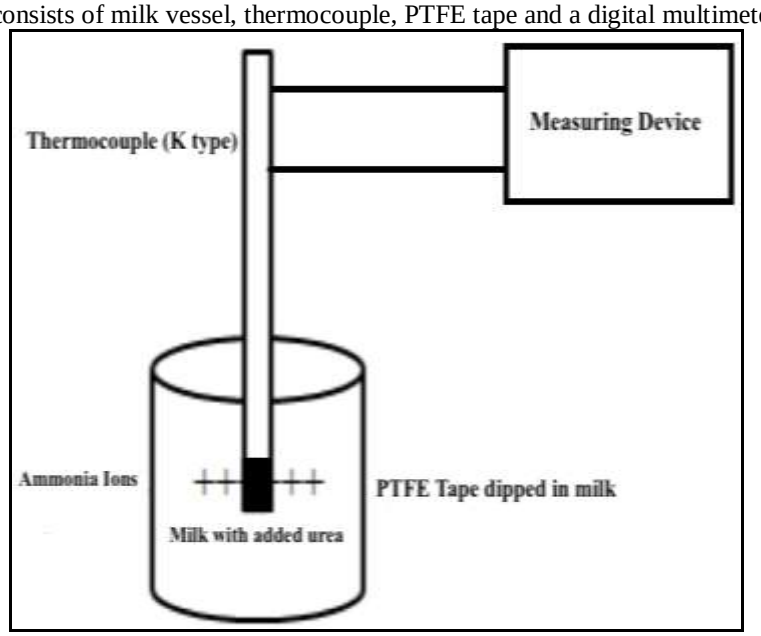

Figure 2. Experimental Setup

The characteristics of each component of the setup are as follows:

A. Milk vessel.

The vessel contains the milk which is to be checked for adulteration. It consists of 100 ml of cow milk, which has 70 mg of Urea in it. The thermocouple (K-Type) with the PTFE tape wound around it is dipped in the vessel and the vessel is stirred. For each concentration of urea taken, the milk is removed and a fresh batch of 100 ml milk is taken and appropriate concentration of urea is added. The urea amount added to the milk was weighed using a precision balance instrument. The thermocouple is cleaned and then dipped into the vessel. The milk used was obtained from a local vendor, meeting the FSSAI standard for the type of milk. This procedure is repeated for all concentrations of urea taken. The specifications of the vessel and surroundings are shown in (Table 2)

Table 2. Milk Vessel Specifications

Specification	Value
Quantity	100 ml
Milk temperature	5 °C
Ambient temperature	27 °C
Urea	70 mg

B. Thermocouple.

The thermocouple is a temperature-sensing device used to sense the temperature change in the PTFE tape. A thermocouple has two junctions, cold junction and hot junction. Because of a temperature difference between the two junctions, voltage is induced between the two terminals of the thermocouple. This voltage is proportional to the temperature difference between the two junctions. The type of thermocouple used is the K-type thermocouple. Type K (Chromel-Alumel) is the most common type of thermocouple. It is accurate, reliable and has a wide range of temperature (-200°C to +1350°C). The output voltage for different temperatures obtained from the datasheet is shown in Table 3 (for reference junction temperature at 0°C).

Table 3. Thermocouple Output Voltage For Different Temperatures

Temperature (°C)	Output Voltage (mV)
4	0.158
5	0.198
6	0.238
7	0.277
8	0.317
9	0.357
10	0.397
11	0.437
12	0.477
13	0.517
14	0.557
15	0.597

C. Tefllon tape.

Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer of tetrafluoroethylene. It is commonly known as Teflon. It has superior chemical properties and thermal properties. In this system, the PTFE tape is wound upon the thermocouple sensing junction and then dipped in the vessel containing milk and urea. The property of Polytetrafluoroethylene is such that it attracts ammonia towards it which increases its temperature. This is sensed by the thermocouple.

D. Measuring Device

The measuring device used in the setup to measure the output voltage was a digital multimeter of industry standard. A digital multimeter is a device used to measure electrical quantities, primarily voltage, current and resistance. It is a standard testing tool used by technicians in the electrical industry.

The multimeter is used to measure the voltage induced between the two terminals of the thermocouple as a result of the increase in temperature of the PTFE tape. The characteristics of the measuring device are shown in Table 4.

Table 4. Characteristics of Measuring Device

Measured Parameter	Characteristic	Value
Voltage	Accuracy	±0.09%
	Max. Resolution	0.1 mV

IV. RESULTS

The following voltage values were obtained for varying concentration of urea.

Table 5. Output Voltage For Different Concentrations Of Urea In Milk

Urea (mg)	Milk (ml)	Output Voltage (mV)
70 (Unadulterated)	100	0.2
120	100	0.25
250	100	0.3
325	100	0.4
400	100	0.5

The output voltage increases linearly with an increase in the urea concentration in milk [Fig. 3.]. Thus, it can be seen that when the concentration of urea increases, the temperature of the PTFE tape increases thereby increasing the voltage induced in the thermocouple

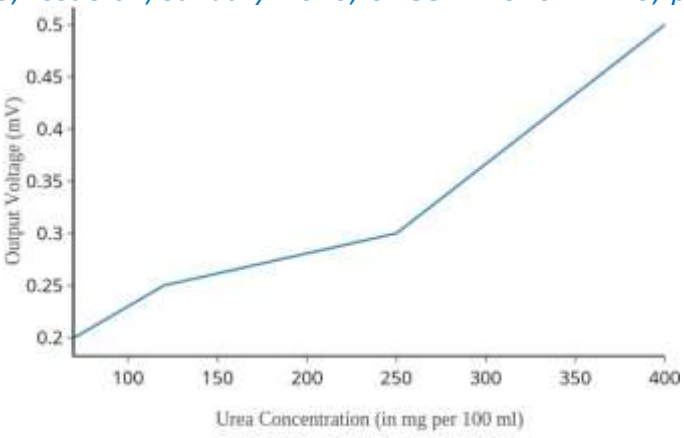

Figure 3. Output Voltage as a function of urea concentration

V. CONCLUSION AND DISCUSSION

The proposed method correctly detects the addition of urea in milk and gives a rough estimation of the amount added. From the graph (Fig. 3), it is observed that the output voltage of the thermocouple increases with an increase in the urea concentration of the milk. Thus, the output voltage is proportional to the urea concentration of the milk. Using the reading for the unadulterated milk as a benchmark (Table 5), we can detect and roughly estimate the extent of adulteration of urea in any sample of milk.

VI. FUTURE SCOPE

Further work can be done on this model by adding an amplifier as the output voltage is in the order of millivolts. Also, further signal conditioning can be done using a bridge circuit in series with an analog to digital converter, which would provide the digital value to a microcontroller that would display the concentration of urea in milk.

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