Detection of Adulteration in Milk using Optical Sensor

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Abstract

Food adulteration is a worldwide concern, and developing countries like India face this problem on a large scale. Not only food, but also fuel has not been spared from this problem. Industries of milk, oil, fuel, etc. being widespread and thriving in this country, face the issue of adulteration as it allows the supplies to easily exploit consumers while gaining profits by compromising on their health. To overcome this problem, various methods were, and still are, being tried and tested but most of these methods include the samples being brought into contact with chemical substances which then cannot be reused. This leads to a lot of wastage of the tested product. This project proposes an idea which can detect adulteration with a 'non-contact' type method by use of optical sensor. It is done by passing laser beam on the sample kept in a transparent glass container which reflects from the surface of the sample. The beam is then detected by optical sensors ; depending upon the variation in reflected light intensity the output of sensor varies. By processing this data, the amount of adulteration done can be inferred. In this way, the sample can be reused again for testing as it does not get contaminated by addition of other substances for testing adulteration.

Keywords: *Raw milk samples, Adulteration, Embedded System, Optical Sensor and Laser*

1. Introduction

Growing commerciality of a product is directly proportional to chances of the product being misused for monetary gains. Especially when the consumer is lacking awareness the manufacturers tend to pry on this and exploit the consumer. Thus dairy is a major industry and adulteration of milk is a very common business that suppliers/manufacturers engage in. Milk is the single most important item of human diet.

When milk leaves the udder of the cow, all the interplay's of adulteration begin. Adulteration in milk are present in various forms, to name a few are water, skimmed milk powder, starch, cereal flours, glucose, sugar, salt, malt dextrin, detergent, nitrate fertilizers, hydrogen peroxide, unhygienic pond water, neutralizers, vegetable oil and urea. The results of a first-of-its-kind survey on milk by the Food Safety and Standards Authority of India (FSSAI) reveal something startling—most Indians are consuming detergents and other contaminants through milk. The study notes that the consumption of milk with detergents in hazardous to health. These adulterants are hazardous and cause irreversible damage to the organs. The Indian Council of Medical Research in an earlier report had mentioned that detergents in milk caused food poisoning and gastrointestinal complications; The other synthetic compounds cause impairments, heart problems, cancer and even death. The immediate effect of drinking adulterated milk with urea, caustic soda and formalin is gastroenteritis but the long-term effects are known to be far more serious. India has a vast and thriving dairy industry committing an adulteration fraud can reap rich profits and exploit poor people if undetected. Diluting the milk with water reduces its nutritive value and also exposes a number of health risks when contaminated water is used. However, history of milk adulteration is very old. Swill milk scandal has been reported in 1850 which killed 8000 infants in New York alone (How we poison our children 1858).

Taking all this into consideration it has become extremely necessary to address this issue right away. Therefore in order to get rid of these problems or at least reduce them to significant level, newer schemes need to be implemented by bringing in sensor based automation technique in this field of detection of adulteration system.

Our main aim is to provide the adulteration technique which is non-contact type method. This can solve the problem of relying on the traditional methods which involves a lot of wastage of sample during the detection adulteration.

2. Other Methods For Detecting Adulteration

(Based on literature Review)

I. Co-axis type non-contact impedance sensor by M. Kaneko et. al.

This paper discusses the non-contact impedance sensor that can measure the mass, viscosity and stiffness on the environment. The developed sensor is composed of a laser displacement sensor and air force supply nozzle. The application of the developed sensor are medical examination of a cancer tissue, medical examination of eye pressure, estimation of human skin age, judgment of the best time for eating fruits or meats. The sensor unit is composed of a laser distance sensor and an air supply adaptor. The key idea is that the hole of air supply adaptor is so designed that the longitudinal axis perfectly coincides with the sensing axis of the laser sensor. To achieve this tuning, we attach a sliding mechanism for the air supply adaptor, which helps us to change the position with observing the laser spot. The air supply system is equipped with a high speed solenoid valve which is the key element of the sensor toward a high speed sensing. The valve can operate with the maximum switching frequency of 500Hz under the supply pressure of 0.05MPa through 0.25MPa. Such a high response allows us to estimate the impedance parameters with high quality as well as high speed. By the relationship between the applied force and the displacement, we can compute the impedance parameters.

II. Optical sensing system for detection of water adulteration in milk by Aditya Dave et. al.

According to this paper the fat content in the milk is not measured. Because the amount of fat in the milk also change the reason have been found that the density of the milk will be affect the refractive index. That change of the index value to be measured by using the optical sensor. For this type of milk sample must be known and the system will fail if a false type is specified. This system is helpful to find the fat content in the milk sample which affects the density of the milk while calculating the adulteration.

III. Performance and Analysis Of Water Adulteration In Milk Using Light Sensing System by J. Arulvaidu et. al.

In this paper they have used the lactometer to measure the fat of the cow milk and buffalo milk. The model techniques are used to measure the percentage of adulteration. The method of adulteration technique was effectively constructed and established based on random sample of milk. Since the amount of milk taken to calculate fat content as well refractive index by using optical sensor. These include finding the fat content of the milk and training the system appropriately to taken into consideration the fat content which affects the density while calculating the adulteration, making the system multi beverage. This includes most of the future work related to the system. Apart from this the system should also be capable of detecting synthetic milk from the real one. Synthetic milk is prepared by adding urea or detergent into the milk and this can have some very serious health effects. This will help to improve the invention.

IV. A prototype of an optical sensor for the identification of diesel oil adulterated by kerosene by Boniphace Kanyathareet. al.

In this study, a prototype of an optical sensor for screening of fake diesel oil is proposed. The device exploits the phenomenon of laser light reflection from a fuel film over a roughened glass plate. The sensing mechanism of the devise is based on the refractive index mismatch between the glass and the fuel sample, and the wetting property of the fuel film over the roughened surface. For the sake of comparison, the refractive index for each of the fuel samples was measured at room temperature with the aid of an automatic temperature controlled Abbe table refractometer. The sensitivity of this prototype optical sensor was tested using training sets of diesel oil samples adulterated with low concentrations of kerosene. Originally, a commercial handheld glossmeter, with a new innovation of a removable sensor head for liquid inspection is presented as a prototype sensor for the screening of possible adulteration of diesel oils with kerosene. The significant difference in the signal readings obtained from carefully prepared training sets of adulterated diesel oil composed of low percentages (5–15%) of kerosene has proven the high sensitivity of the developed sensor. The ability to detect low concentrations of kerosene in diesel using the hand-held prototype sensor proves its high sensitivity compared to a high-accuracy Abbe refractometer. They envisage that this proposed sensor could, in the future, be made accessible to the authorities as a mobile fake fuel measurement unit.

V. Optical sensor for determining adulteration in a liquid sample by L. M. Baliet. al.

An optical sensor for determining the proportional composition of two liquids in a mixture is developed. It is based on observing changes in the reflected light intensity at the glass-mixture interface brought about by the changes in the proportion of one liquid over that of the other in the mixture. Sample mixtures for this investigation here have been prepared by changing the concentration of substances such as kerosene and diesel fuel in a fixed volume of petrol. A procedure for identifying as well as evaluating the concentration of kerosene or of diesel fuel or of a mixture of the two in a sample of petrol has been reported. Evaporation of these sample mixtures is carried out by exposing them to a constant flow of air at the same temperature as that of the sample mixtures. Experimental determination of changes in the reflected intensities are carried out by using an arrangement in which one of the two isosceles surfaces of a right-angled isosceles prism is interfaced with the sample mixture. Experimentally determined values for some of these changes are compared with the theoretical estimates for them obtained from Fresnel’s equation

3. Problem Statement

From all the technical papers that we have reviewed, we have come to a conclusion that when incident beam is reflect from the fluid the sensor catch the reflected beam light as well as room light because of this system doesn’t give us better accuracy to measure the adulteration of fluid.

4. Design and Methodology

I. Block Diagram

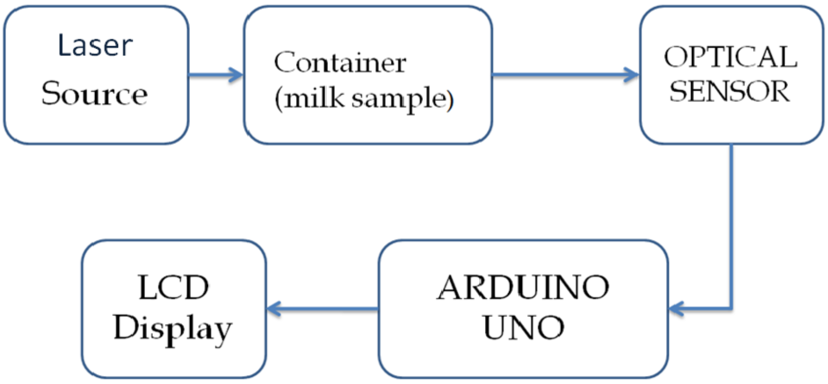


Figure 1. Block Diagram

II. Component Description

- **Laser source:**

Laser is a device that stimulates atoms or molecules to emit light at particular wavelengths and amplifies that light, typically producing a very narrow beam of radiation. The emission generally covers an extremely limited range of visible, infrared, or ultravioletwavelengths. Many different types of lasers have been developed, with highly varied characteristics. *Laser* is an acronym for "light amplification by the stimulated emission of radiation."

Features**:**

Name	Red Dot-Projecting Laser
Wavelength(nm)	650nm
Output power(mW)	5mW, 10mW, 20mW, 50mW, 80mW, 100mW
Beam Diameter at aperture(mm)	4.2mm×2.5mm
Beam divergence (mrad)	5 mrad
Beam mode	TEM
Focus adjustable?	Yes
Operating voltage(v)	DC＝3.0V
Operating current(mA)	I<900mA
Operating temperature(℃)	10℃～30℃

Figure 2. Laser source

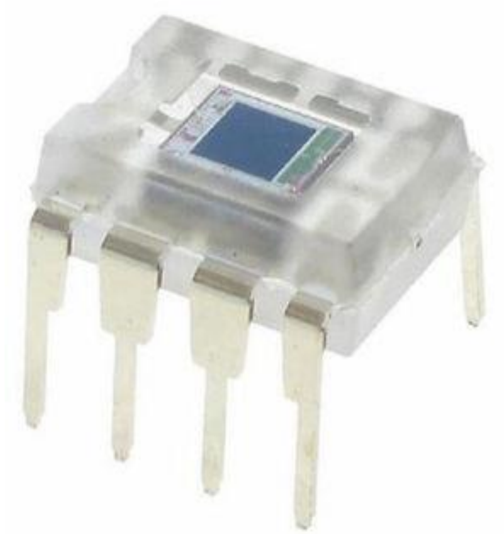
- **Container**:

It is any plain transparent borosilicate glass container in cylindrical shape with refractive index around 1.517

Figure 3. Glass container

- **Optical Sensor:**

Optical Sensor used is OPT101 is a monolithic photodiode with on-chip trans impedance amplifier. Output voltage increases linearly with increasing light intensity. It is a large-area photodiode integrated with an optimized operational amplifier that makes the OPT101 a small, easy-to-use, light-to-voltage device. It has a very large measurement area that collects a significant amount of light, and thus allows for high-sensitivity measurements. It has a wide spectral response with a maximum peak in the infrared spectrum, and a useable range from 300 nm to 1100 nm.



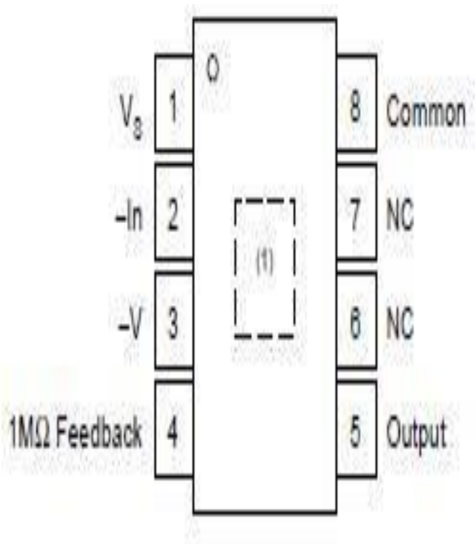


Figure 4. OPT101 Pin configuration

III. Flowchart

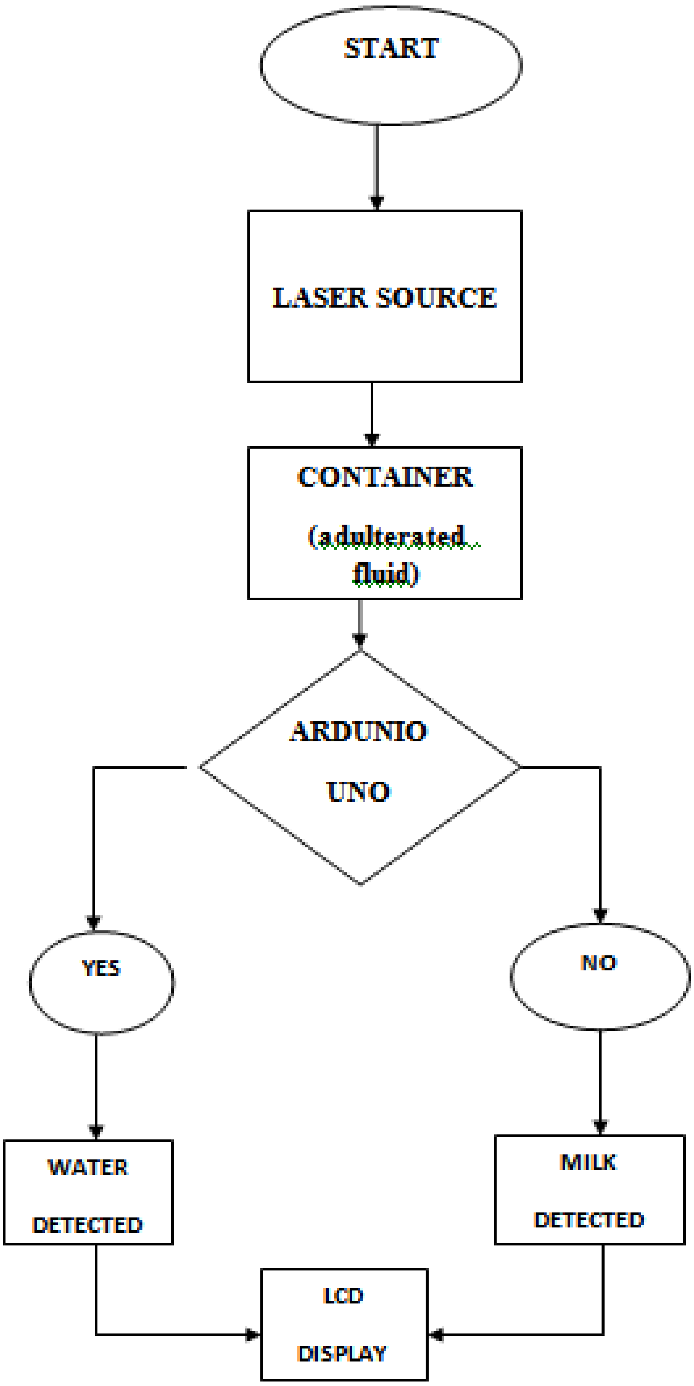


Figure 7. Flowchart

5. Setup and Implementation

We have fixed the laser source on the stand. We experimented the initial part. The light is allowed to get incident inside on the glass container containing adulterated milk. As the sensors are affected by surrounding light, we have enclosed the setup inside the wooden box.

Figure 8. Experimental setup

Initially, we took 400ml of pure milk in a transparent glass beaker. We then positioned the laser so that the beam fall on the milk surface.

Figure 9. Different milk glass container

A part of the light refracted and a part of it gets reflected. We keep the OTP101 sensor where the reflected ray falls to measure the intensity. The OTP101 sensor is first mounted on a bread board along with other necessary components for testing.

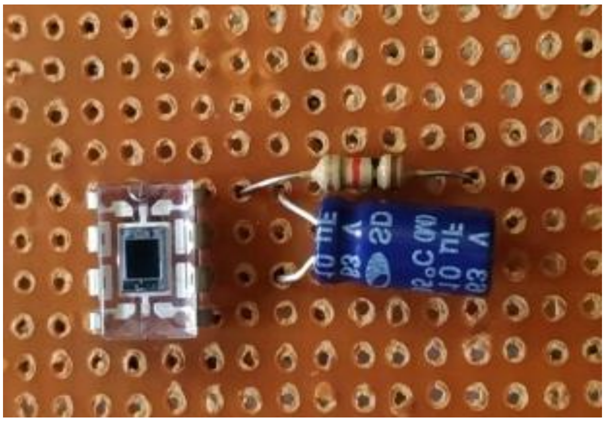


Figure 10. OPT101 module

We used Arduino Uno to process the data sensed by the sensor and display it temporarily on the serial monitor. The readings are in the form of Volts proportional to intensity. Next, we added water to the pure milk. The same procedure is repeated for the adulterated milk. We then take a new set of readings which are lesser than previous. This is because, when the light reflects from the pure milk, less amount of light gets refracted and more of it gets reflected. When water is added, the R.I. of milk gets reduced and lesser light gets reflected.

6. Results

Following table consists of observed readings of the sensor:

Table 1. Readings of sensor

0%water(Pure milk)	10% water	20% water
850	830	810
870	840	800
900	820	815
925	835	805
950	832	811

7. Conclusion and Future Scope

Optical sensors which we used provide with better results compared to other methods previously used. But this does not include the fat content in the milk sample. Fat content changes the milk density which affects the refractive index of the milk. Cow's milk has less fat content than buffalo's milk. This includes the future work of comparing the amount of adulteration depending on fat content.

Also detection of synthetic milk prepared by adding urea and detergent can also be detected by further improvements in this method.

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