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Quantitative and Qualitative Analysis of Milk Parameters using Arduino Controller

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Abstract: This paper presents the design and development of Arduino controller based system to detect the parameters of milk. The parameters include milk quantity, pH, CLR and SNF. The Ultrasonic sensor, pH sensor and lactometer are used to measure the quantity, pH and CLR of the milk respectively. Using the value of FAT and CLR the value of SNF can be calculated and studied qualitatively. The sensors are interfaced with the Arduino controller. The software developed enables to read the parameters and display them on the LCD panel. The milk quantity is displayed in litres. This is a low cost and efficient tool to detect adulteration of the milk.

Keywords: Milk; Adulteration; Arduino controller; pH meter, SNF, CLR.

I. INTRODUCTION

Now-a-days the milk adulteration is mostly detected using various chemical tests. These methods are tedious, time consuming and costly. Also the knowledge of the tests is necessary. The nutritional value of milk to human health needs no introduction; it also has traditional impact on Indian society. At the same time it is alarming that many vendors adulterating it with water, detergents, caustic soda, starch, formalin, urea, ammonium sulphate, sodium carbonate which have harmful effect on the human health [1, 2]. The greed for money has pushed them to the extent of producing synthetic milk which has no nutritional content.

"Adulteration" is a legal term meaning that a milk product fails to meet federal or state standards. Adulteration is an addition of another substance to milk in order to increase the quantity of the milk in raw form or prepared form, which may result in the loss of actual quality of milk [3].
Milk adulterated is mainly done for financial gain but it can also be adulterated due to unhygienic conditions such as processing, packaging, transportation, distribution etc. Water is the most common adulterant used which decreases nutritional value of milk and lowers the quality of milk. Many analytical techniques have been developed to measure the adulterations quantitatively and qualitatively. The review of milk adulteration, its effects on human health and the techniques of detection of adulteration has been done [2].
India is world's largest milk producer country. The farmers took more interest in dairy industry and more number of co-operative dairies are formed in villages. Dairies collect, test and rate the milk. Simple lactometer test is done to detect quality of milk. There is no low cost alternative available to check the adulteration at primary level. Hence it was intended to develop the simple, low cost, battery operated and handy tool to test the quality and quantity of the milk.

The project development is based on the principle of detection of milk adulteration using electronic sensors. The advantages such as size, weight, power consumption, speed etc. can only be offered by embedded systems, so it was decided to use embedded system in the development.
This project describes the development of the Arduino controller based system that measures and displays the milk parameters;

* Quantity of milk in litres
* pH
* CLR (Corrected Lactometer Reading)
* SNF (Solid but Not Fat)

The ultrasonic sensor, pH sensor and the Lactometer are implemented to measure the quantity, pH and the CLR respectively. Using the value of CLR, SNF is calculated. The milk parameters are displayed on LCD panel.

II. EXPERIMENTAL

As discussed above the development of the system is as shown in the block diagram

Fig 1: Block diagram of Milk parameter measurement system

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As shown in the block diagram of the system, working of the system is divided into two sections:

1. Measurement of milk parameters using sensors:
 i. Quantity measurement
 ii. Quality measurement
a. pH measurement
b. CLR measurement
2. Acquiring the parameter values, processing them using microcontroller and display them on LCD panel.

1. Measurement of milk parameters:

i. The milk quantity is measured using Ultrasonic sensor HC-SR04 based on SONAR principle of measuring distance to an object. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package. Distance from 2cm to 400 cm can be measured. The distance measured is finally calibrated in to litres using algorithm. The experimental setup to measure milk quantity is as shown in photograph (fig. 2).

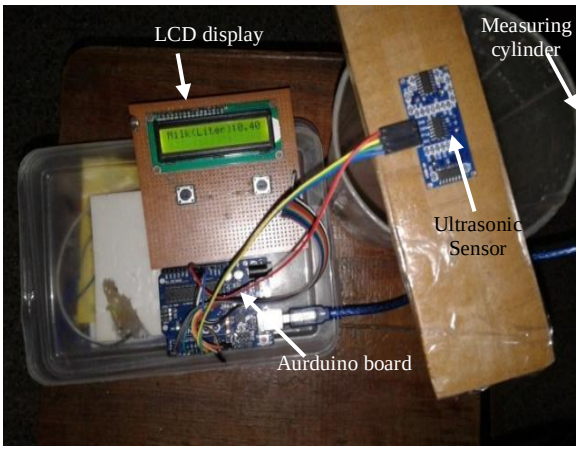

Fig.2: Milk quantity measurement setup

Here the distance measurement formula is expressed as: L = C * T, where L is the distance measured, C is ultrasonic velocity in air and T is Time (transmitting to receiving). The reading set comprised of 10 readings of the sample of known amount.

ii. Quality measurement

a. pH-measurement: The pH sensor MS pH 07 is implemented for pH measurement. The output voltage (analog) of the sensor is proportional to the pH value of the milk. The sensor is first calibrated using standard sample (distilled water). The Arduino Uno microcontroller has built-in analog to digital convertor (ADC). The pH sensor output is fed to analog input pin A0 of the microcontroller. The algorithm allows reading the pH value and displaying it on the LCD panel. The experimental setup for pH measurement is as shown in fig. 3 (photograph 2). The reading set comprised of 20 readings of the same quality sample and volumetric dilution of sample is done by mixing measured quantity of adulterant in it.

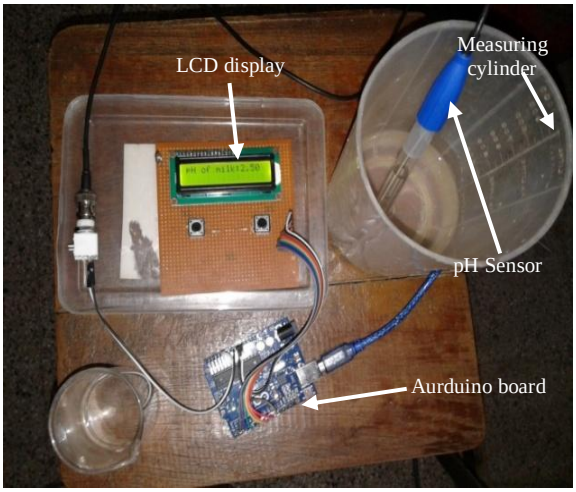

Fig.3: The pH mesurement setup

b. Measurement of CLR using Lactometer :

The Solids-Not-Fat (SNF) means proteins, lactose, minerals, acids, enzymes, vitamins contents of the milk [6]. It is the total solid content minus the fat content. The total milk solids are the sum of Fat and SNF. The SNF can be calculated using following formula [8];

SNF = (CLR reading/4) + (Fat x 0.21) + 0.36.

The CLR is measured using usual lactometer based on the principle of specific gravity [5]. The lactometer mainly contains glass tube containing mercury or lead shots at bottom side. Pure milk has a specific gravity of 1.026 to 1.032 grams per ml. The water content in the milk can be determined by measuring the specific gravity. The experimental setup consists of lactometer immersed in milk with a circular plate mounted on its neck as a reference for Ultrasonic sensor. The distance of reference varies w.r.t. the change in specific gravity of the milk and in turn changes the output of Ultrasonic sensor. Thus the output voltage of the Ultra sonic sensor is proportional to the specific gravity (water content) of the milk. The Ultrasonic sensor is first calibrated using pure milk. Then by adding known amount of water every time the output voltages are recorded.

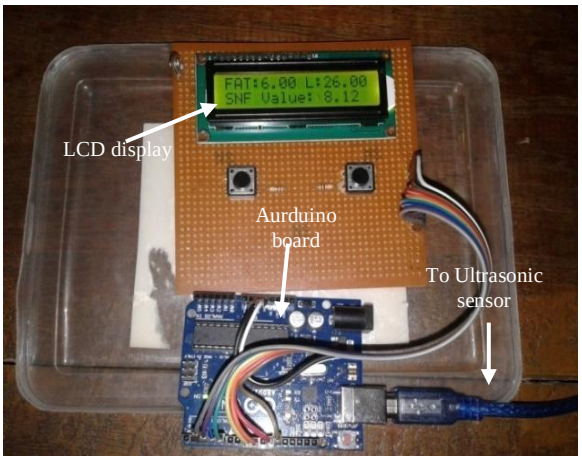

Fig 4: The CLR and SNF measurement setup

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Further the proportionality constant is determined and is used in the algorithm so that the CLR reading is directly displayed on the LCD panel. Finally the SNF is calculated by using values of standard FAT and CLR reading of Lactometer using above formula. The fig. 4 (Photograph 3) shows the CLR and SNF measurements displayed on the LCD panel. Reading set comprised of 20 readings. The experimental measurements are carried out using same quantity samples of buffalo and cow milk.

2. Processing and Display:

The Arduino ATmega328 controller board has been incorporated in the work due to its attractive features such as, low operating voltage and current, sufficient program memory, 14 digital input/output pins, 06 analog inputs, 4 UARTs, 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header etc.

As shown in the block diagram (fig.1) and as discussed above the sensors are interfaced separately (different setups) with the microcontroller board. Firstly the calibration of sensor is done for every setup and then the parameters are measured. The acquired data is then processed using algorithm and then are displayed on the LCD panel. The flow charts for three setups are given in the table below;

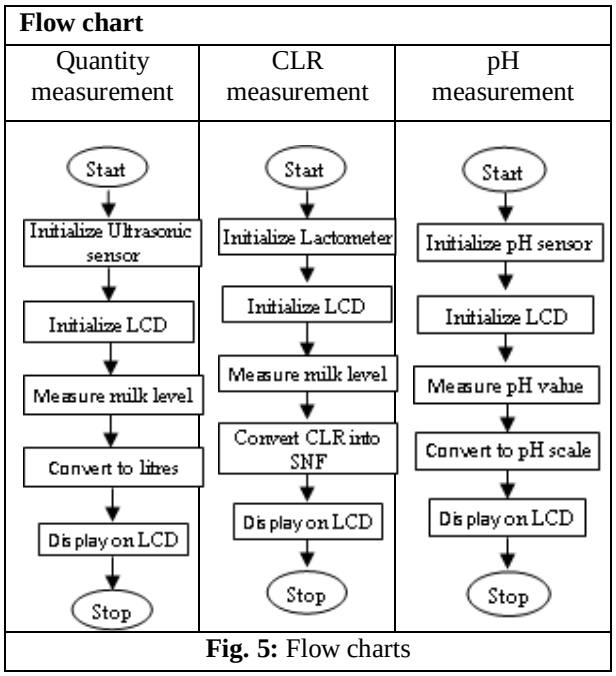

Fig. 5: Flow charts

III. RESULT AND DISCUSSION

a. The quantity measurement was found to be accurate and precise within acceptable variation. However the system is susceptible to position of sensor and shape of the container. Hence more perfect set up is needed to get accurate measurement.

b. The CLR measurement was found to be accurate and precise within the range of sample values. However it was also susceptible to any small variation in the sample. Hence a more suitable set up would be needed to get the accurate readings.

c. The pH measurement is found to be accurate and precise within the range. However it was also susceptible to a minute variation in the sample. Hence the sample must be consistent in its composition to get a correct reading. This can be achieved by stirring or homogenizing the sample with a stirrer. A more suitable setup would be needed to raise the accuracy of the system. Provision to clean the sensor using buffer solution for every sample is a must.

IV. CONCLUSION

The development and application of low cost and efficient milk parameter detection and analysing system using Arduino controller has been presented in this paper. The system allows the measurement of quantitative (volume) and qualitative parameters (pH, CLR and SNF). The developed system is smaller in size and weight; it works with low power consumption and has a fast response. Thus it can be implemented for portable applications.

Future work will be focused on improving overall accuracy of the system. Also efforts could be made to make the system handier (design miniaturization) so that it could be freely implemented in field operations.

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