A Survey Report & a Proposal of Cost Effective Method for Milk Quality Analysis

Rajashekhar B. S.[1] Baijanath Tharu[2] Kamal Kumar Yadav[3] Deepak[4] Dinesh J.[5]
[1]Assistant Professor [2,3,4,5]B.E. Student
[1,2,3,4,5]Department of Electronics & Communication Engineering
[1,2,3,4,5]Sambram Institute of Technology, Bangalore, India

Abstract— Milk is one of the most nutritious liquid in the world. It is rich in very high amount of protein, minerals and vitamins. Besides, it also contains high amount of fat which may bring health hazards to the consumer. So, it is crucial to know the quality of the milk before it is consumed. This paper presents a literature survey of milk quality analysis and their shortcomings and also proposes a method to determine the quality of the milk by performing quantitative analysis using light combined with Embedded System. This method also presents a technique to keep the error as low as possible. Use of light makes this method fast. The cost of light transmitter and the light sensor used in this method are very low. Consequently, the overall cost of the device is also reduced.

Key words: Milk Quality, Photo Sensor, Milk Analysis, Low Cost

I. INTRODUCTION

Milk is a white liquid obtained from the mammary glands of the mammals. It is the primary source of nutrients for the infant mammals. Milk also contains colostrum that carries the antibodies from mother and reduces the risk of many diseases in infants [1]. Besides colostrum, it also contains nutrients like protein, fat, vitamins and minerals. The milk extracted from domestic mammals like cow, buffalo, sheep, etc. have been commercialized. In 2011, dairy farms produced 730 million metric tons of milk from 260 million dairy cows all over the world. [2]. India is one of the largest exporter of skimmed milk powder [3].

The composition of milk may vary among the various breeds and species of mammals. Human milk contains 1.1% protein, 4.2% fat, 7.0% lactose (a sugar), and supplies 72 kcal of energy per 100 grams on an average. Similarly, cow's milk contains 4% protein, 3.6% fat, and 4.6% lactose, 0.7% minerals, and supplies 66 kcal of energy per 100 grams on an average. Water constitutes the medium in which other milk constituents are in either dissolved or suspended form.

The fat globules present in milk are approximately 2 to 5 microns in size. Fat in milk is composed of a number of glycerid - esters of fatty acids which on hydrolysis gives a mixture of fatty acids and glycerol. The fat associated substances are phospholipids, cholesterol, carotene and fat soluble vitamins (A, D, E, K). The protein in milk is mainly composed of casein, lactaglobulin, lactalbumin, milk serum albumin, immuno globulins etc. Casein forms the 80% of the total milk protein. Lactalbumin and lactaglobulin are known as 'whey or serum proteins'. They are also present in colloidal state and are easily coagulated by heat [4].

In recent years, a number of techniques have been proposed and implemented for qualitative and quantitative analysis of milk using spectroscopic analysis. These techniques are highly reliable. However, they are highly sophisticated and it is difficult to make a device which uses spectroscopic principle.

II. LITERATURE REVIEW

A. Earlier Methods

Tsenkova R along with other authors have presented a paper in 1999 which uses NIR spectroscopy to determine the content of fat, protein and lactose in un homogenized milk [5]. They have performed NIR spectroscopic analysis of the milk by using variable wavelength ranging from 400 nanometres to 2500 nanometres with sample thicknesses of 1 mm, 4 mm, and 10 mm. The results obtained from their research is of high importance. They conclude that the fat content is found to be accurate at the wavelength from 700 nm to 1100 nm with sample thickness of 10 mm and for protein content of sample thickness 1 mm.

Emanuele Viviani along with other three authors have presented a paper in 2016 which uses ultrasonic spectroscopic technique for quantitative analysis of milk [6]. The ultrasonic technique is non-invasive in comparison to optical, chemical and electrical technique. The samples also do not require pre-treatment as in other techniques. So, this technique is highly efficient and reliable.

Moncayo S along with other authors have presented a paper in 2017 which uses Laser Induced Breakdown Spectroscopy [7]. LIBS is based upon atomic emission technique. Though this technique offers high accuracy, it is very difficult to implement in a device for quantitative analysis of milk. Even though it is implemented, the cost of the device becomes very high.

B. Advantages of Earlier Methods

The advantages of the methods researched by authors mentioned in Earlier Methods mainly includes the accuracy of the result produced by their experimental set up. Use of sophisticated technique guaranteed high accuracy. They also produce quick results. Some of them are non-invasive as well.

C. Disadvantages of Earlier Methods

The major disadvantage of the methods mentioned above is cost. Since they use spectrometers and other high-quality testing devices, they are high in cost. The real time implementation of these techniques is very difficult and requires highly skilled man power even to analyse the results obtained from them.

Considering the high cost of the devices designed in the earlier methods, in this paper, we propose a method using the scattering principle of light in milk to make a device that can determine the fat and protein content in the milk. This device will be less in cost and may serve small scale dairies and other dairy business.

III. PROPOSED METHOD

A. Principle of Working

In this paper, we propose a method based upon the scattering theory for measuring fat and protein content in the milk [8]. This principle states that when a light with high intensity is passed through a sample of a milk, then some of the incident light is transmitted through the sample while others are scattered or absorbed by the constituents in the milk. The transmittance of the light is due to the presence of water in the milk. The big fat and protein molecules scatter the most of the incident light in a direction perpendicular to the incident light.

Let, the intensity of the incident light, scattered light and absorbed light be I_I, I_S and I_A respectively. According to principle of energy conservation, we have

$$I_I = I_S + I_A.$$

The absorption of the light by fat and protein in milk sample is very less at a normal room temperature. So, the absorption intensity can be neglected. If we can determine the scattered light intensity and transmitted light intensity, then an empirical relation between fat and protein and intensity of light can be obtained. If we take readings of scattered and transmitted light intensities for different concentration of milk, we can calculate the ratio of scattered to transmitted light intensities.

Let the ratio of scattered to transmitted light be y. Also let the concentration of milk fat and protein be x. It is seen from the scattering principle that y depends upon x, so we can write y as a function of x given by

$$y = f(x).$$

On plotting, the ratio of scattered to transmitted light against the theoretical fat and protein values, we can apply a suitable curve fitting technique to empirically determine f(x). If we solve the equation for x, it gives us the quantity of milk fat and protein.

B. Block Diagram of Proposed Device

The proposed device consists of a light transmitter which transmits light of wavelength of 650 nm with a power of 5 milliwatts. Two photo sensors are used, one for measuring transmitted light and another for measuring scattered light. The photo sensor to measure transmitted light is placed on the opposite side of the light transmitter i.e. at 0^0 with the incident light. The photo sensor to measure scattered light is kept perpendicular to the incident light i.e. at 90^0 with the incident light. The sample of milk is taken in a beaker of 100 ml placed in between the light source and the first photo sensor. The light source and photo sensors are controlled by a microcontroller, Arduino UNO. The LCD display is used to show the fat and protein content in the milk. The light source and photo sensors are kept inside a box so that there is no interference of outside light. Fig.1. shows the elaborate block diagram of the proposed device.

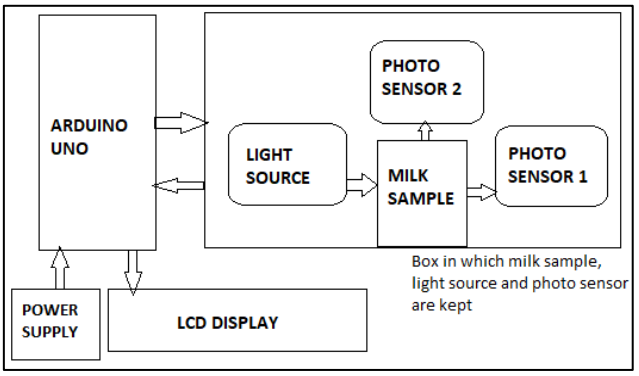

Fig. 1: Block Diagram of the Proposed Device

C. Calibration Procedure for the Device

In order to calibrate the device, following steps will be performed:

1) 1.5 ml of sample of homogenized milk, whose fat and protein content are known, is taken in a beaker of 100 ml.
2) The beaker is placed in between the light source and the photo sensor, and the transmittance voltage is measured. The reading is tabulated in a table.
3) The table consists of the concentration of milk, theoretical value of fat and protein, and transmittance voltage, scattered voltage and ratio of scattered voltage to transmittance voltage (ratio).
4) The concentration of milk in the beaker is increased by 1.5 ml in each step till the milk concentration reaches to 70 ml and the transmittance voltage and scattered voltage is measured. The ratio of scattered voltage to transmittance voltage (ratio) is determined. The table is updated with the entries of the reading.
5) A graph of ratio (X-axis) against theoretical value of fat and protein (Y-axis) is plotted.
6) A curve fitting technique is used to determine the formula that will relate the fat and protein content of milk with the ratio.
7) This formula can be used in the Arduino program to measure the protein and fat content of the unknown sample of milk.

D. Advantages of the Proposed Device

The device proposed is simple and does not use highly sophisticated spectroscopic analysis to find the fat and protein content of the milk. The real time implementation of the device is easy and is low in cost. Since, in this method, we have used light and light sensors which are very sensitive, the result is quickly obtained and it is also non-invasive.

IV. EXPECTED RESULTS

It is expected that the measurement of milk fat and protein can be done rapidly with greater accuracy since we have used light and light sensors. A great effort has been taken to keep the position of the photo sensor at the mentioned angle with respect to the incident light because a slightest error in the position of the sensors can bring a lot of errors in the measurement. It is expected that the result obtained can be made within an error below 0.5%. However, if a linear error is obtained in the readings, it may be corrected using mathematical techniques to increase the accuracy of measurement.

V. CONCLUSION

Thus, a survey report for milk quality analysis is presented. A method to determine the content of fat and protein in the milk is proposed. The accuracy and the error of the proposed method will be calculated when the device is implemented. If the error is very less, this device may serve as a low-cost fat and protein measurement device and can be used in many small-scale dairies and other milk processing industries effectively.

ACKNOWLEDGMENT

It is immense pleasure to acknowledge our HOD, Dr. C. V. Ravishanakar, Department of Electronics and Communication Engineering, Sambhram Institute of Technology, for his help and motivations provided to us. We are also grateful to our project coordinators Dr. Veena and Prof. Padmashree S who created a research friendly environment in our department that helped us to complete this work.

REFERENCES

[1] Godhia Meena and Patel Neesah, "Colostrum - Its Composition, Benefits as A Nutraceutical: A Review," Current Research in Nutrition and Food Science Journal, vol. 1, pp. 37-47, 2013.
[2] "Food Outlook – Global Market Analysis"(pdf), Food and Agriculture Organization of the United Nations, pp. 8, 51–54, May 2012.
[3] "Government scraps incentive on milk powder exports to check prices". Time so findia-economictimes. http://articles.economictimes.indiatimes.com/2014-07-09/news/51247854_1_milk-powder-smp-exporters-milk-prices
[4] Robert Jenness, Noble P. Wong, Elmer H. Marth and Mark Keeney, "Fundamentals of Dairy Chemistry," 1998.
[5] R. Tsenkova, S. Atanassova, Y. Ozaki and K. Itoh, "Near-Infrared Spectroscopy for Dairy Management: Measurement of Unhomogenized Milk Composition," Journal of Dairy Science, 1999.
[6] Emanuele Viviani, Daniele Salvalaggio, Cristina Bertoni and Antonio Boscolo, "Milk quality analysis based on a novel ultrasound spectroscopy method, Sensors Applications Symposium (SAS), 2016 IEEE.
[7] Moncayo S, Manzoor S, Rosales JD and Anzano J, "Qualitative and quantitative analysis of milk for the detection of adulteration by Laser Induced Breakdown Spectroscopy (LIBS)," Caceres JO, Food Chemistry, 2017.
[8] Donald J. Dahm, "Review Explaining some light scattering properties of milk using representative layer theory," Journal of Near Infrared Spectroscopy, vol. 21, pp. 323-339, 15 October, 2013.

