IDENTIFICATION OF ADULTERATION IN MILK USING EMBEDDED SYSTEM

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering

in

Electronics and Telecommunication

by

Ansari Arham	15ET15
Nishith Shetty	14ET41
Amey Mali	12ET35
Anwar Kazi	15DET60

Under the guidance of

PROF. RAHUL B.KHADASE

Department of Electronics and Telecommunication Engineering

Anjuman-I-Islam's Kalsekar Technical Campus
Sector 16, New Panvel , Navi Mumbai
University of Mumbai

2018-2019

CERTIFICATE

Department of Electronics and Telecommunication Engineering
Anjuman-I-Islam's Kalsekar Technical Campus
Sector 16, New Panvel , Navi Mumbai
University of Mumbai

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Supervisor Examiner

Head of Department Director

Project Report Approval for Bachelor of Engineering

This project entitled **" IDENTIFICATION OF ADULTERATION IN MILK USING EMBEDDED SYSTEM "** by **Ansari Arham , Nishith Shetty, Amey Mali , Anwar Kazi** is approved for the degree of **Bachelor of Engineering in Electronics and Telecommunication** .

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……………………
Ansari Arham
(15ET15)

…………………….
Nishith Shetty
(14ET41)

…………………….
Amey Mali
(12ET35)

…………………….
Anwar Kazi
(15DET60)

Date:

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Ansari Arham (15ET15)
Nishith Shetty (14ET41)
Amey Mali (12ET35)
Anwar kazi (15DET60)

ABSTRACT

This paper presents the design and development of Arduino controller based system to detect the parameters of milk. The parameters include pH, CLR and SNF. The 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. Also with the help of IOT (Internet of Things) process the milk industry should be able to send the real time reading information of milk to the government so that it helps to overcome the illegal things such as milk quality during the production of milk pocket.

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

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Chapter 1

Introduction

1.1 Introduction

Adulterants like soap, acid, starch, table sugar and chemicals like formalin may be added to the milk. Most of the it chemicals used as adulterants are poisonous and cause health hazards. Adulterants are mainly added to increase the shelf life of milk.

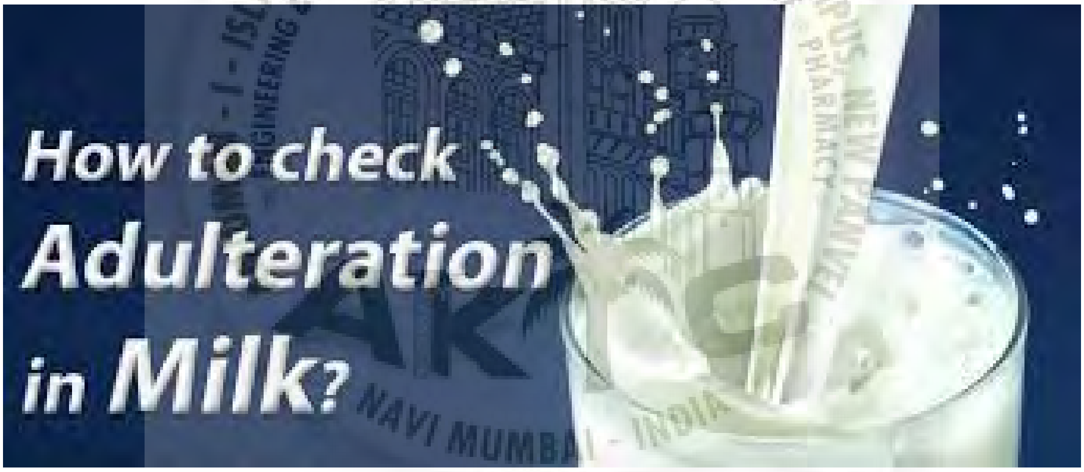

Figure 1.1: Milk Adulteration

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. 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.

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. India is worlds largest milk producer country. The farmers took more interest in dairy industry and more number of co-operative dairies are formed in villages. Simple lactometer test is done to detect quality of milk.

Figure 1.2: Milk Adulteration

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: pH CLR (Corrected Lactometer Reading) SNF (Solid but Not Fat) The pH sensor and the Lactometer are implemented to measure the pH and the CLR respectively. Using the value of CLR, SNF is calculated. The milk parameters are displayed on LCD panel. A proof of concept application using Information and Communication Technology (ICT) in the dairy sector was developed by the Centre for Electronics Governance at the Indian Institute of Management, Ahmedabad (CEG-IIMA).

The application aims at helping the dairy farmers with timely messages and educating them on the care for their milch cattle and enhance the production of quality milk. It also aims at assisting the dairy unions in effectively scheduling and organizing the veterinary, artificial insemination, cattle feed and other related services. The application uses Personal Computers at the milk collection Centres of the Dairy Cooperative Societies (DCS) having connectivity to an Internet Service Provider (ISP). The application includes two components - a Dairy Portal (DP) and a Dairy Information Services Kiosk (DISK). This paper presents IIMA-CEGs efforts to design and implement the DISK and Dairy Portal. [2] This Milk Producer Group Resource Book is part of a series of practical field guides for people working in smallscale dairying in developing countries. These field guides are produced by the Animal Production and Health Division of the Food and Agriculture Organization (FAO) of the United Nations.

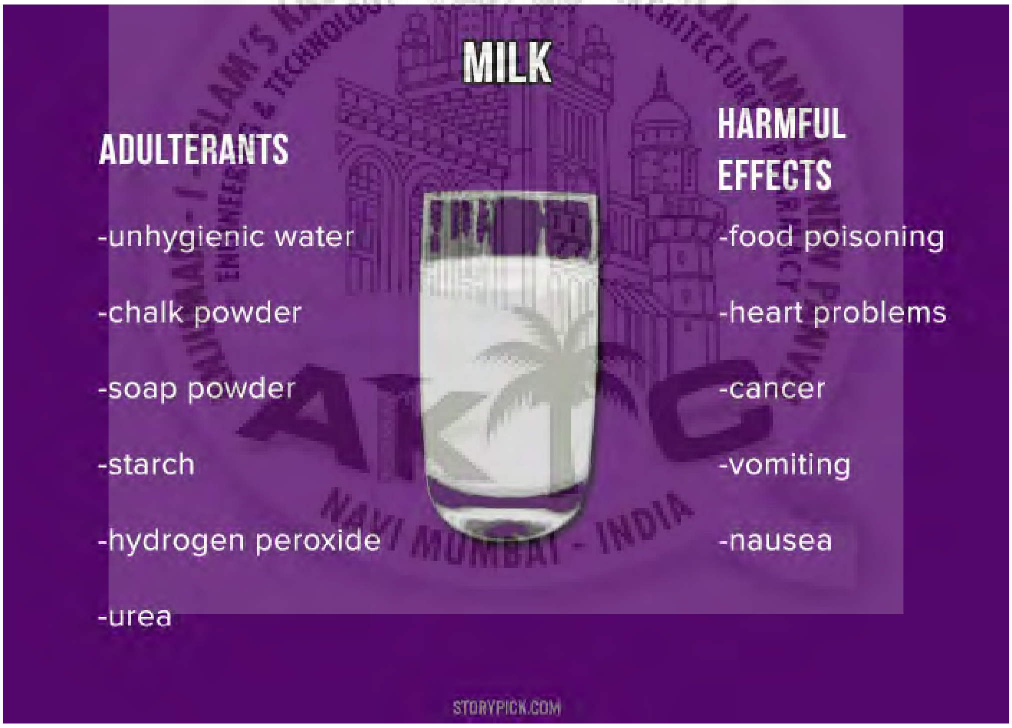

Figure 1.3: Harmful effects of Adulteration

Milk producers can increase their income and utilise their skills and resources better if they are working in groups. This book aims to promote the organization of small-scale milk collection and processing as a sustainable, income-generating activity for household food security. It also tries to be a means to improving the safety, quantity and quality of milk and milk products available for consumers in developing countries. The intended readers are (future) leaders of milk producer groups, extension workers, project staff and group promoters who are working to set up milk producer groups,and those developing already existing groups at village level in rural areas. Some excellent FAO booklets exist on working with small groups (see information sources and references). They complement this book which has been written specifically for milk producer groups. This Milk producer group resource book aims to play a role in poverty alleviation in developing countries in a gender sensitive and sustainable way. [5]

1.2 Motivation

Food adulteration is a global concern and developing countries are at higher risk associated with it due to lack of monitoring and policies. However, this is one of the most common phenomena that has been overlooked in many countries. Unfortunately, in contrast to common belief, milk adulterants can pose serious health hazards leading to fatal diseases. This paper presents a detailed review of common milk adulterants as well as different methods to detect the adulterants both qualitatively and quantitatively. Department

Chapter 2

Literature Survey

2.1 Identification of Adulteration in Milk using Embedded System

2.1.1 Weaknesses

Recent incidents of adulteration involving infant formula, other milk products and pet food with the industrial chemical melamine revealed the weaknesses of current methods widely used across the domestic and global food industry for determining protein content in foods.reliance on 19th century methods primarily the Kjeldahl method and the combustion (Dumas) method for measuring total protein content in foods and the lack of more specific methods allowed for the adulteration of proteinbased foods with melamine and related nonprotein compounds in 2007 and 2008.

2.1.2 How to Overcome

The move has been initiated by various food and drug administration bodies to ensure the edible quality of the milk at high degree thereby generating the need of milk testing chemicals The primary function of milk testing chemicals are improve the safety and hygiene quality of milk. Moreover, milk testing chemicals are help to increasing the yield of milk and other dairy products.

Chapter 3

Technical Details

3.1 Methodology

1. Arduino microcontroller:

Arduino is a flexible programmable hardware platform designed for artists, designers, tinkerers, and the makers of things. Arduinos little, blue circuit board, mythically taking its name from a local pub in Italy,has in a very short time motivated a new generation of DIYers of all ages to make all manner of wild projects found anywhere from the hallowed grounds of our universities to the scorching desert sands ofa particularly infamous yearly arts festival and just about everywhere in between. Usually these Arduino based projects require little to no programming skills or knowledge of electronics theory, and more often than not, this handiness is simply picked up along the way.Central to the Arduino interface board, shown in Figure 1, is an on board microcontroller think of it as a little computer on a chip.

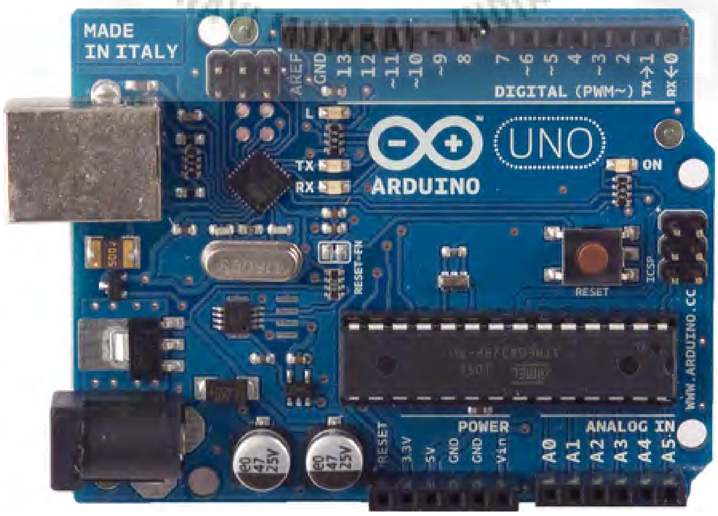

Figure 3.1: Arduino

This microcontroller comes from a company called Atmel and the chip is known as an AVR. It is slow in modern terms, running at only 16Mhz with an 8-bit core, and has a very limited amount of available memory, with 32kilobytes of storage and 2 kilobytes of random access memory. The interface board is known for its rather quirky designjust ask the die hards about standardized pin spacing but it also epitomizes the minimalist mantra of only making things as complicated as they absolutely need to be. Its design is not entirely new or revolutionary, beginning with a curious merger of two, off the-shelf reference designs, one for an inexpensive microcontroller and the other for a USB-to-serial converter,with a handful of other useful components all wrapped up in a single board. Its predecessors include the venerable BASIC Stamp, which got its start as early as 1992, as well as the OOPic, Basic ATOM, BASICX24,and the PICAXE.

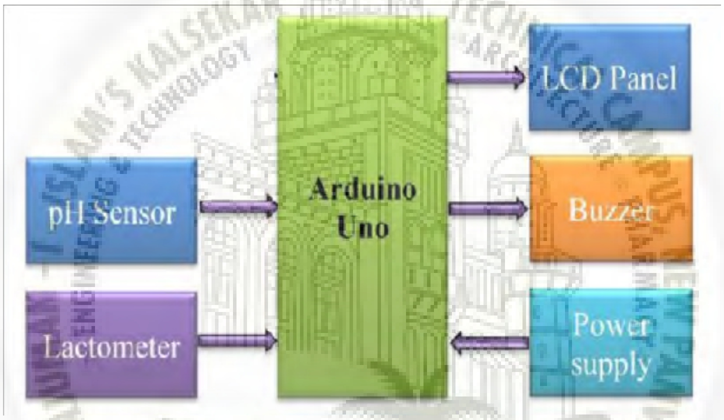

Figure 3.2: Block diagram of Milk parameter measurement system

2. CLR measurement:

The specific gravity of the milk is measured using a Lactometer and the temperature deviation of milk is taken into consideration and correction applied, the lactometer is called Correct Lactometer Reading (CLR). The Auto CLR is an instrument incorporating electronics to observe the lactometer reading .It is a patented instrument of its manufacturer Solid State Technologies. In this case the manual process is preserved, only electronics is added to it make observation error free and apply the temperature correction automatically.

Construction:

A 120 ml cylinder is used to contain the milk sample .The lactometer is suspended in the freely movable and vertically arranged cylinder. The original position oflactometer is obtained by taking water in the cylinder and allowing the lactometer to attain a undisturbed position in which it shows 0 on the scale.

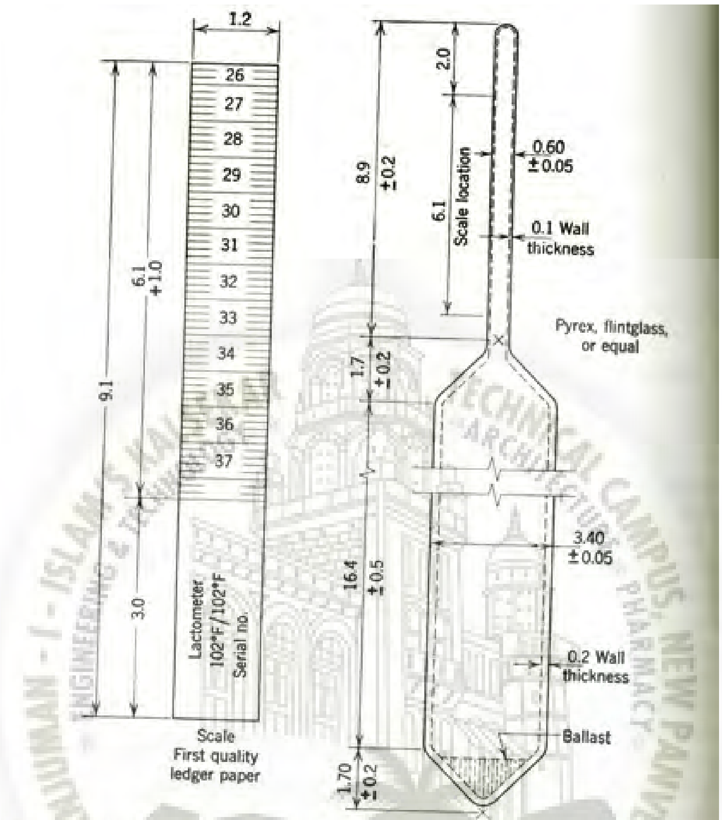

Fig. 64. Modified lactometer, U.S.D.A. Bulletin ARS-73-10. (Degrees are in centimeters.)

Figure 3.3: Lactometer

Working:

Take 120 ml of milk is in cylinder. The lactometer moves in a vertical direction and attains a fixed floating position. The lactometer reading is calibrated on scale on lactometer itself .The reading on the lactometer corresponding to the level of the milk gives the lactometer reading. But in Auto CLR we measure this vertical movement electronically. The upper tip of the lactometer is attached to the float of the type is used in motorcycles to indicate fuel level. This float moves vertically along with motion of lactometer. Using a strain gauge attached to the float, the resistance change is calibrated as a measure of the lactometer reading.

The Solids-Not-Fat (SNF) means proteins, lactose, minerals, acids, enzymes, vitamins contents of the milk. 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: SNF = (CLR reading/4) + (Fat x 0.21) + 0.36.

- Total Solids can be estimated from the corrected lactometer reading (L).

$$TS = \frac{(L-1)*1000}{4} + (1.22 \times fat\%) + 0.72$$

- Once TS is found, SNF can be estimated

$$SNF = TS - fat\ \%$$

$$milk\ \ price = litres\ of\ milk \times \left\{ \frac{(fat\ \% \times fat\ price)}{100} + \frac{(SNF\ \% \times SNF\ price)}{100} \right\}$$

Figure 3.4: Formula

3. 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.4.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.

Figure 3.5: PH Measurement Setup

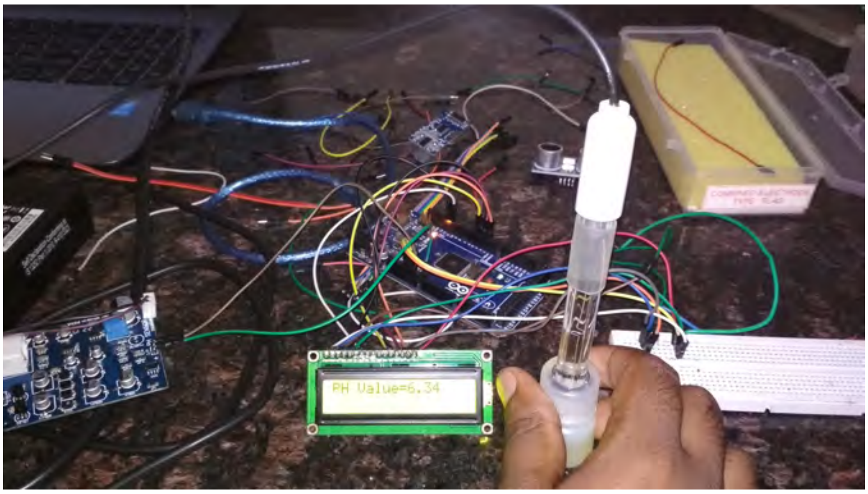

Figure 3.6: PH Measurement Setup

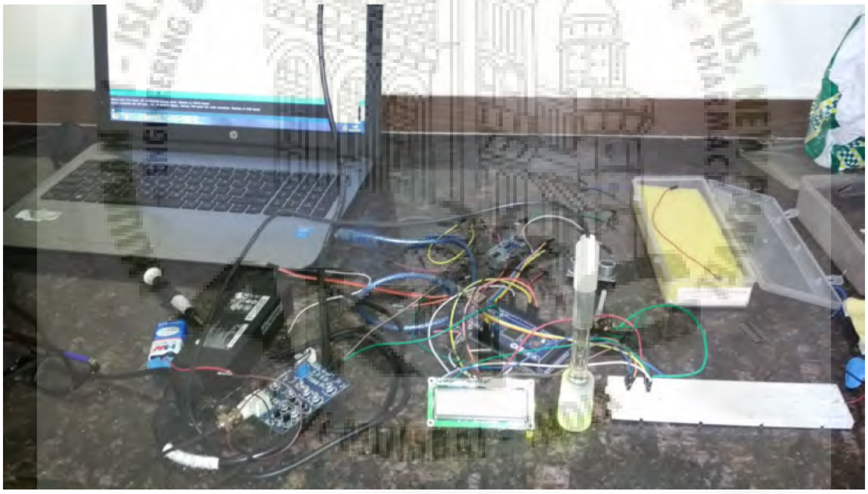

Figure 3.7: PH Measurement Setup

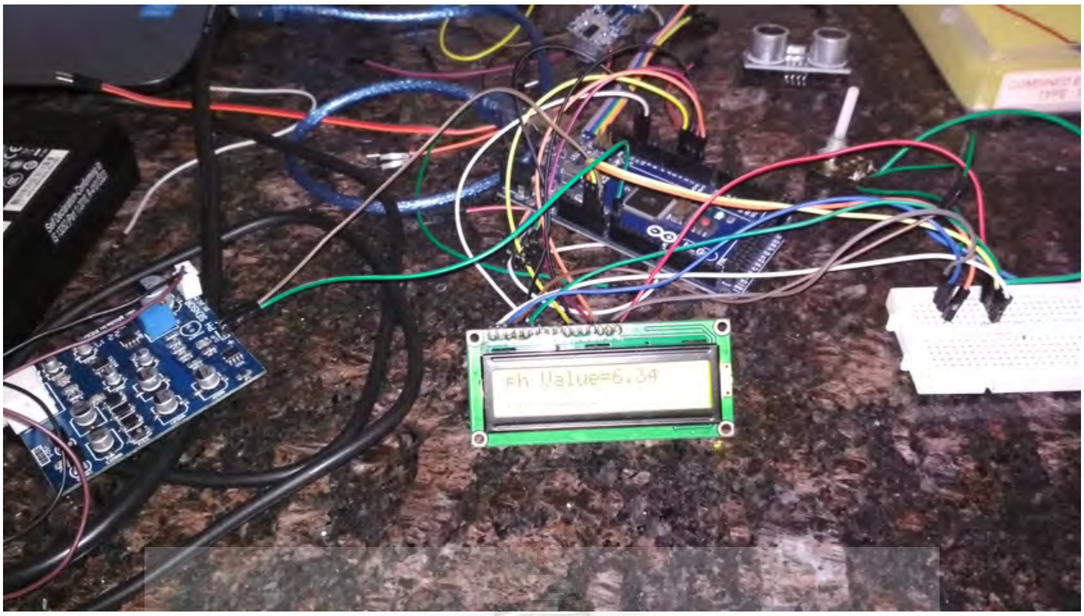

Figure 3.8: PH Measurement Setup

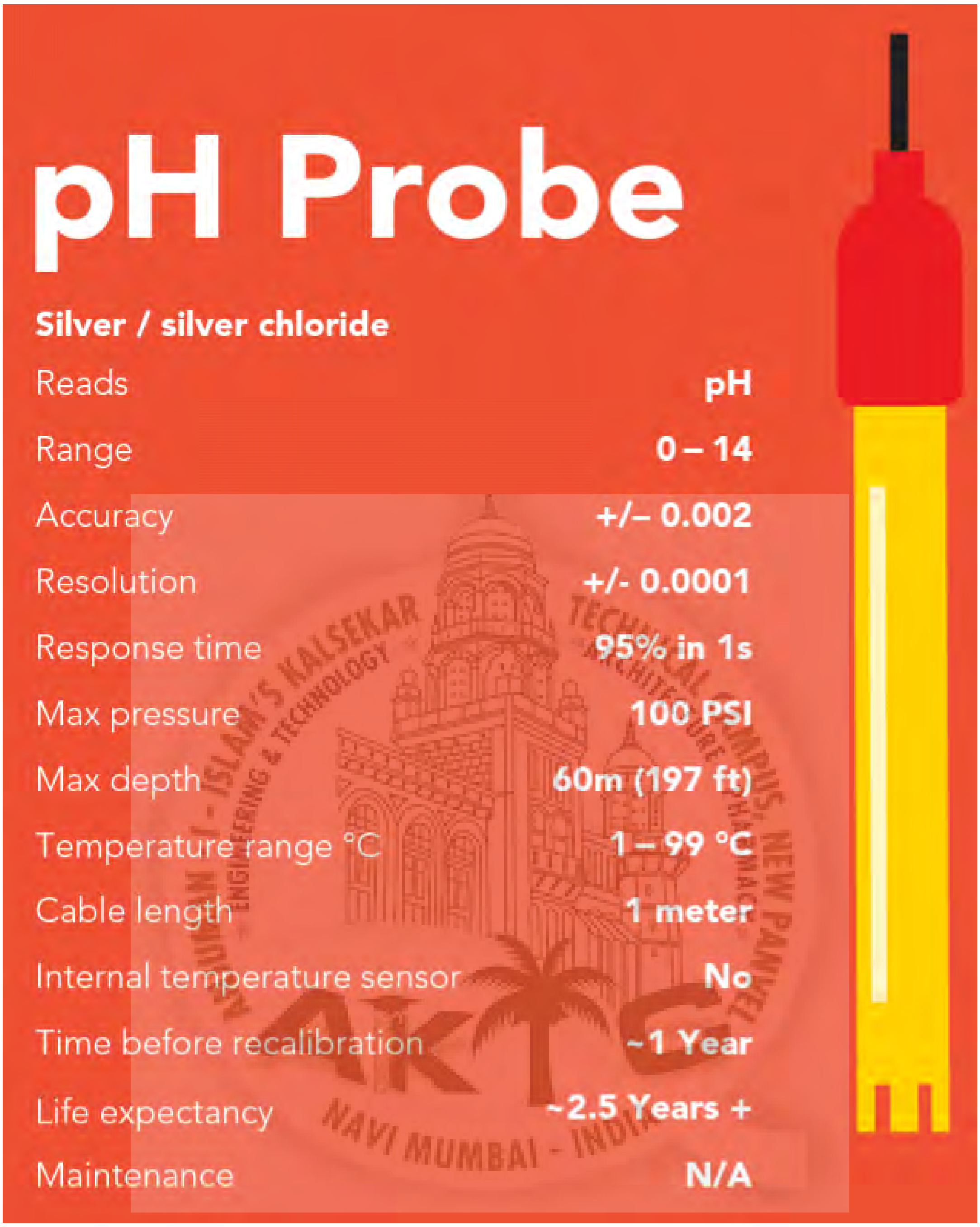

Figure 3.9: Operating Principle

Figure 3.10: Specifications and Applications

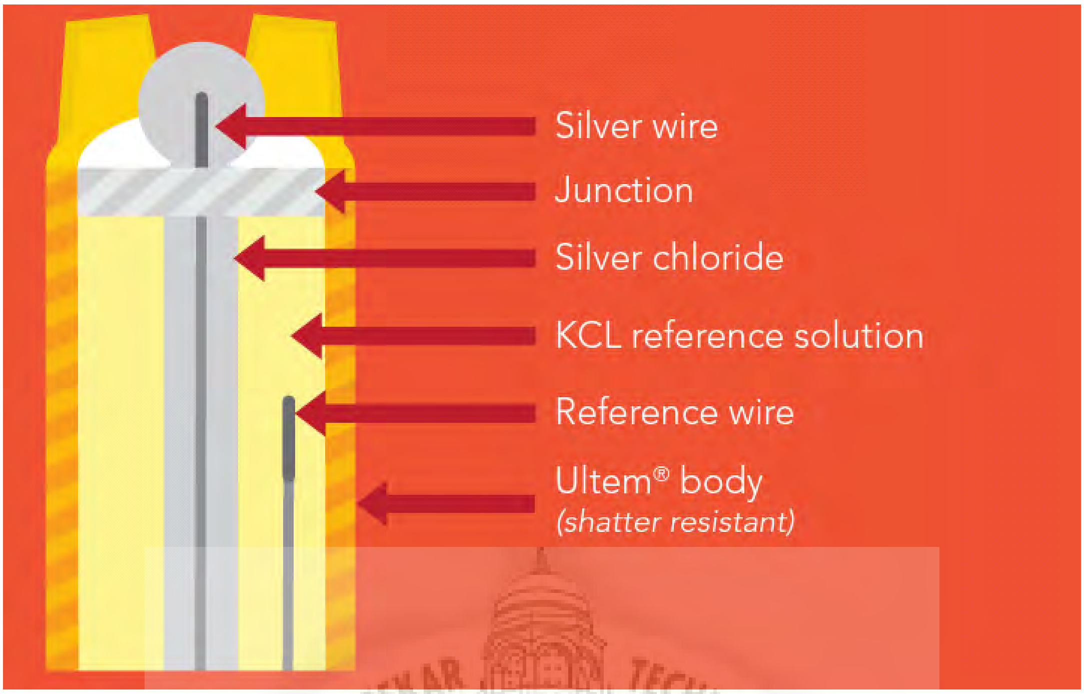

Figure 3.11: PH ELECTRODE

Operating Principle:

A pH (potential of Hydrogen) probe measures the hydrogen ion activity in a liquid. At the tip of a pH probe is a glass membrane. This glass membrane permits hydrogen ions from the liquid being measured to defuse into the outer layer of the glass, while larger ions remain in the solution. The difference in the concentration of hydrogen ions (outside the probe vs. inside the probe) creates a VERY small current. This current is proportional to the concentration of hydrogen ions in the liquid being measured.

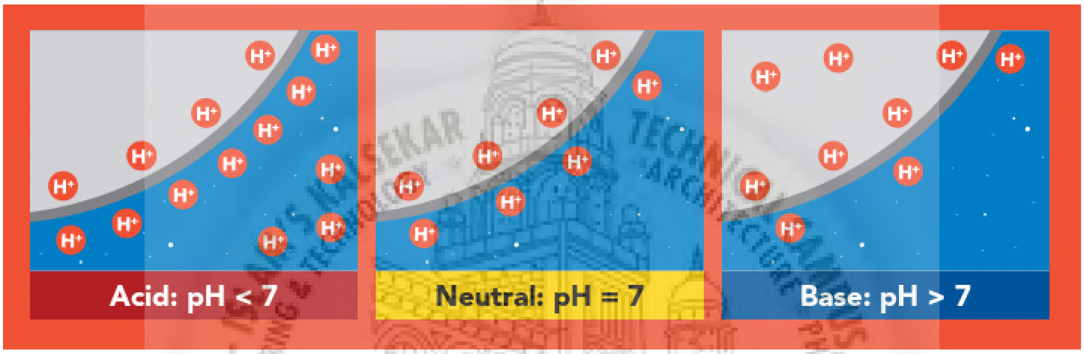

Figure 3.12: Operating Principle

3.2 Project Requirements

3.2.1 Software Requirements

Arduino Software

Figure 3.13: ARDUINO SOFTWARE

3.2.2 Hardware Requirements

PH Sensor

Figure 3.14: PH SENSOR

Lactometer

Figure 3.15: LACTOMETER

LCD Display

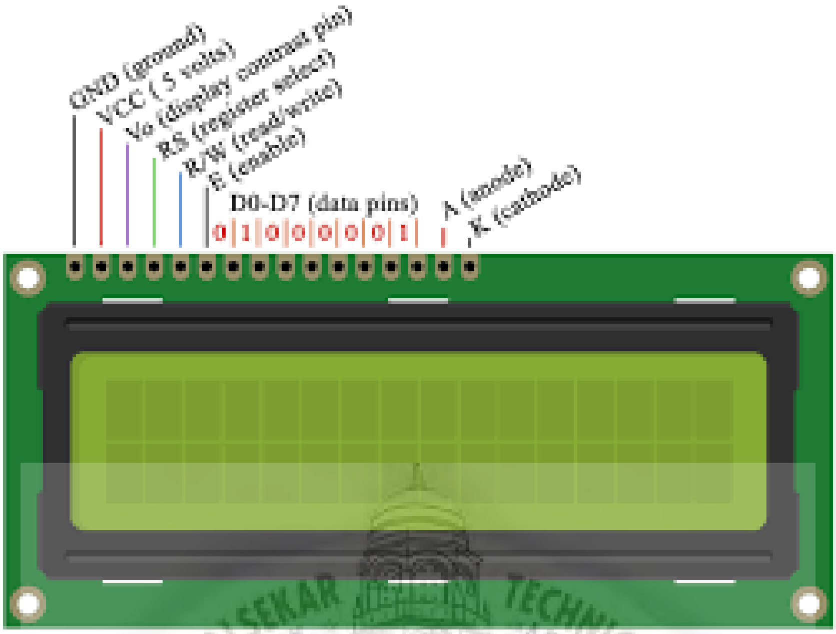

Figure 3.16: LCD DISPLAY

LCD CONNECTION WITH ARDUINO

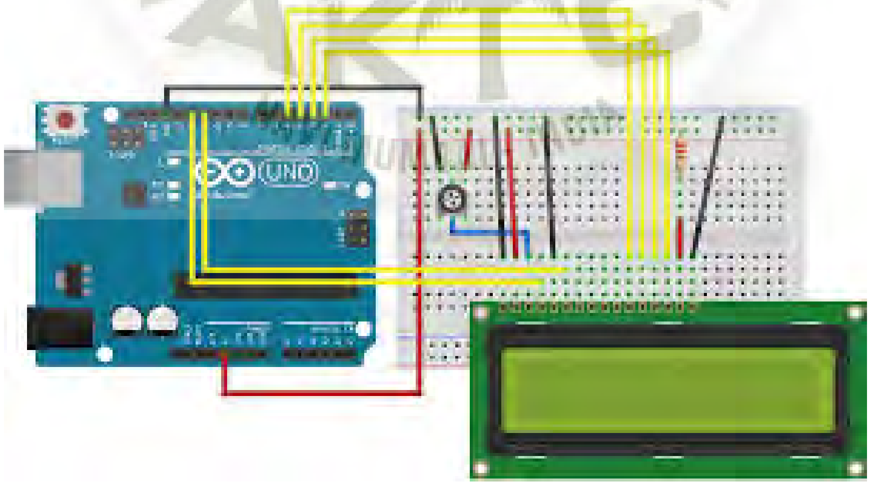

Figure 3.17: LCD CONNECTION

Chapter 4

Implementation

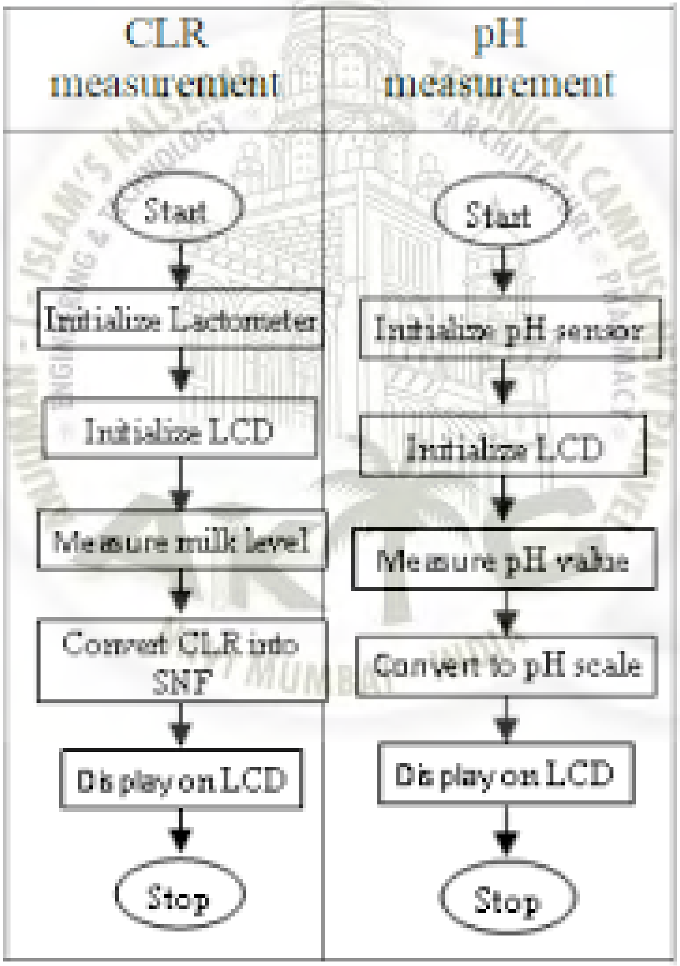

Figure 4.1: Flow Chart

Chapter 5

Results and Discussions

Lactometer Reading (LR) and specific gravity:

The results of LR and Specific gravity of all milk samples are shown in Fig 5.1. The cow milk showed the highest LR and specific gravity i.e., 30.0 and 1.03, respectively. Similarly LR of buffalos milk ranged 26.0 to 29.0 and corresponding to specific gravities of 1.026 to 1.029, respectively. Moreover, the milk of goat samples showed LR and specific gravity in the range of 27 to 30 with the corresponding specific gravities of 1.027 to 1.030, respectively. Further comparison of LR values, the Sheep milk samples showed LR and specific gravity in the range of 27 to 29 with the corresponding specific gravities of 1.027 to 1.029, respectively. These results showed that goat and sheep milk is non-significantly different but cow and buffalo milk is significantly different from each other. According to Lampert[11], the lactometer is used as an aid in detecting milk to which water might have been added. Normal milk rarely has a specific gravity (at 60F) less than 1.030 (LR = 30) and therefore a lower lactometer reading would justify suspicion that the milk had been adulterated. The results of specific gravity are discussed in Fig 5.1.The value of specific gravity of cow milk (1.03), which resembles the above-mentioned value, but the results of other three species (buffalo, goat and sheep) are quite different.

Source	LR (Range)	LR (Mean)	Sp. Gravities (Range)	Sp. Gravities (Mean)
Buffalo	26-29	27.65	1.02-1.02	1.02
Cow	28-34	30.0	1.02-1.03	1.03
Goat	27-30	28.65	1.02-1.03	1.02
Sheep	27-29	28.05	1.02-1.02	1.28

Figure 5.1: Lactometer Reading (LR) and Specific gravities of different milk samples

PH and total titratable acidity:

pH and total titratable acidity of each milk sample were noted at fresh stage. The titratable acidity test is a simple acid-base reaction. This test allows a calculation of percentage acidity in milk. The values for pH and titratable acidity in various milk samples are given in Fig 5.2. The cow milk showed maximum pH value (6.65) while sheep milk samples showed maximum titratable acidity (0.181 percent). The minimum pH value (6.58) was of sheep milk while the minimum titratable acidity (0.15 percent) was of the cow milk samples. The results showed that buffalo, cow, goat milk are non-significantly different from each other but sheep milk is significantly different from all other three species. In case of pH, all the four species are non-significantly different from each other. As shown in Fig 5.2 in results, the pH values of cow milk (6.65) and of buffalo milk (6.68) showed almost similar results observed by Gervilla et al.[18], who studied the pH of bovine milk (6.66) but value of goat (6.59) and of sheep milk (6.58) showed little variation.

Campbell and Marshall[19] found the maximum value of milk containing a higher apparent acidity is 0.23 percent. In the present study buffalo milk showed the lowest value (0.11 percent) of TTA in contrast to it the sheep milk showed the highest value (0.18 percent). While the value of cow (0.15 percent) and goat milk (0.13) falls between these two extremes.

Sources	TTA (Range)	TTA (Mean)	pH (Range)	pH (Mean)
Buffalo	0.11-0.18	0.133	6.60-6.9	6.64
Cow	0.12-0.19	0.15	6.63-6.68	6.65
Goat	0.11-0.17	0.135	6.34-6.68	6.59
Sheep	0.16-0.19	0.181	6.40-6.80	6.58

Figure 5.2: Total Titratable Acidity (TTA) and pH of different milk samples

Fat, solid non-fat and total solids:

Usually the determination of fat contents is considered to be a satisfactory measure for estimating the overall quality of fresh milk but where skimming of milk as well as addition of water or dried milk powder is suspected, estimation of total solids in the representative samples may also be necessary.

Mean values and their respective range values of milk samples collected from different species of animals are given in Fig 5.3. The representative samples collected from different species showed that the fat and total solid contents of the milk of buffalo were 5.25 and 14.04percent, respectively. Similarly, samples collected from different species showed that the fat and total solid contents of the milk of cow were 4.56 and 13.73 percent, respectively.

Similarly, the fat and total solid contents of the milk of goat were 4.73 and 13.55 percent respectively and the fat and total solid contents of the milk of sheep were 8.96 and 18.53 percent, respectively which is quite high as compared to other samples.

Sources	% Fat (Average)	% Fat (Range)	Standard Deviation (SD)
Buffalo	5.25	4.0-6.5	0.96
Cow	4.56	4.0-5.0	0.41
Goat	4.73	3.9-5.7	0.63
Sheep	8.96	8.0-9.6	0.56

Figure 5.3: Percentage Fat of different milk samples

The results of fat percentage showed that buffalo, cow, goat milk are non-significantly different from each other but sheep milk is significantly different from other two species. The results of SNF showed that cow and goat milk is non-significantly different from each other but sheep and buffalo milk are significantly different from all other three species. The total solids contents found by two different methods that represented almost the same results statistically as shown in Fig 5.4. The total solids contents of different species showed non-significant with each other.

Sheep milk showed the highest value (8.96 percent) while the buffalo milk showed the lowest value (5.25 percent). The value of goat and cow milk lies in-between these two extremes. These values of cow and goat are quite similar to the finding of Hanjra et al.[20]. The percentage fat contents of buffalo milk showed similarity with the finding of Athar and Ali[8], while sheep values find support with the results of Banda[5] and finding of Foltys[21] also support the present study. The values of total solids were discussed in results in Fig 5.4. In that sheep milk showed the highest percentage of total solid (18.53 percent) while the goat milk sample showed the lowest value (13.55 percent). Results of buffalo (14.04 percent) and cow milk (13.73 percent) ranges between the values of TS contents of the above mentioned two species. Finding of Athar and Ali[8] showed little similarity with the present study they observed that buffalo and cow milk of NARC dairy farm contained 6.5 and 16.6 percent and 3.8 and 12.8 percent fat and total solids respectively. Ibeawuchi and Dalyop[22], who studied the composition of fresh cow milk also, support the present study to little extent. The finding of Gervilla et al.[18] who studied the fat and total solid contents of bovine milk (7.69 and 18.17 percent, respectively) also supports present study.

Sources	% TS (Average)	% TS (Range)	Standard Deviation (SD)
Buffalo	14.04	12.73-15.90	1.19
Cow	13.73	13.43-14.34	0.28
Goat	13.55	12.60-15.17	0.80
Sheep	18.53	17.48-19.50	0.68

Figure 5.4: Percentage Total solids of different milk samples

However, the results of SNF found in this study showed significant difference (P¡0.05) among the milks of buffalo (8.79 percent) and of goat milk (8.92 percent). In contrast, the SNF of milk samples obtained from cow and sheep (9.17 and 9.71 percent, respectively).

Total solids of milk other than fat are called solid-non-fat or SNF. The variations are related to seasons and lactation stage; although other reasons are less important, such as environmental conditions and breed of the animal etc[23]. The results of percentage SNF were discussed in Fig 5.5. Athar and Masud[24] and Hanjra et al.[20] reported similar results.

Sources	% SNF (Mean)	%SNF (Range)	Standard Deviation (SD)
Buffalo	8.79	8.28-9.40	0.32
Cow	9.17	8.43-10.14	0.49
Goat	8.92	8.53-9.47	0.29
Sheep	9.71	9.48-10.1	0.22

Figure 5.5: Percentage SNF of different milk samples

Lactose Contents:

Lactose is the principal carbohydrate of milk. Lactose contents of the milk collected from different species are given in the Fig 5.6.

Milk samples collected from sheep showed the lowest lactose contents (3.57 percent) and that of goat milk showed highest value (4.66 percent), respectively. The lactose contents of milk collected from buffalo and cow showed 3.92 to 4.03 percent, respectively. The results obtained from graph showed that goat was significantly different from others and buffalo and cow milk were non-significantly different from each other.

As the results shown in Fig 5.6, the value of percentage lactose is highest in goat milk (4.654 percent) while lowest value was shown by sheep milk (3.568 percent), but the values of buffalo milk (3.918 percent) and of cow milk was (4.03 percent) that ranges between the values of above mentioned two species. These results are partly supported by the Eckles et al.[10] and Hanjra et al.[20]. The US public health service milk ordinance[6] requires the lactose contents to be around 4.8 percent, which is quite near to the value of the goat milk.

Sources	% Lactose (Mean)	Range (%)	Standard Deviation (SD)
Buffalo	3.92	3.28-4.8	0.003
Cow	4.03	3.0-4.6	0.045
Goat	4.66	4.0-5.5	0.033
Sheep	3.57	3.0-4.2	0.003

Figure 5.6: Percent Lactose contents of milk collected from different species

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

- With the help of system we are able to judge the quality of milk more accurately ,as well as farmer will get daily updates of record and immediate payment status for this milk delivered
- Also farmers will get the proper benefits according to the quality of milk and consumer we will get the good quality of milk . The elimination of manual registers for all kind of information and data storage can be additional benefits.
- The milk collection parameter such as weight FAT and CLR which are measured by our system as same as the existing more developed system with low cost.

6.2 Future Scope

- Daily updates of payment and milk parameter to customer through GSM can be done
- By using automatic system for CLR measurement we can reduce the time to measure milk quality
- By interfacing milk system with compact thermal printer , we can get billing receipt on the spot

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