VIBRO-SENSING TECHNOLOGY FOR REAL-TIME MILK QUALITY ASSESSMENT

A.Basheeth[1], A.Boomika[2], G. Gokul[3], B. Logasree[4], R. Poorani[5]

Selvam College of Technology, Namakkal, Tamil Nadu, India.

Abstract

Milk is quite frequently consumed liquid food and is high in nutrients, making it excellent for people of all ages. The safety of dairy products is primarily dependent on the quality of milk (raw milk). Because temperature effects the quantity of bacteria in raw milk, choosing the right temperature can extend the raw milk's storage time. As a result, implementing a raw milk temperature monitoring system is especially vital. This system consists of hardware and software design. Each challenge has a remedy, and technological advancements enable the majority of those solutions. These adulterants reduce the nutritional value of milk and may cause major health issues. To address this sociocultural issue, we developed a Milk Spoilage Detection System that uses an ESP32 microcontroller and different sensors such as temperature, pH, LDR, and a vibration motor to analyze milk quality. Different factors are also measured and categorized. Finally, the output can be witnessed on a virtual panel using IoT technology.

Keywords

Vibro-sensing technology; internet of things (IoT); Real-Time Milk spoilage detection; Remote monitoring solutions*;*

INTRODUCTION

Milk is a staple food consumed by people of all ages due to its high nutritional value. However, maintaining its quality and safety is a major concern, as improper storage conditions can lead to bacterial growth and spoilage.
Temperature plays a crucial role in preserving raw milk, making real-time monitoring essential to ensure its longevity and safety. Traditional methods for milk quality assessment are often time-consuming and require laboratory testing, making them impractical for everyday use.To address this issue, we propose Vibro-Sensing technology for real-Time milk quality assessment, which leverages modern sensor technology and IoT integration for real-time milk quality assessment. The system employs an ESP32 microcontroller, along with sensors such as temperature, pH, LDR, and a vibration motor, to detect spoilage. These parameters are analyzed and displayed on a virtual panel using IoT, enabling remote monitoring and timely intervention. This innovative approach provides a cost-effective, efficient, and non-intrusive solution for ensuring milk safety in households and dairy industries.

1.MAIN SECTION- I
1.1 EXISTING SYSTEM

A practical and efficient solution to this problem is proposed in this article: a vibration-based milk spoilage detection method called VibMilk that utilizes the ubiquitous vibration motor and inertial measurement unit (IMU) of off-the-shelf smartphones. The method detects spoilage based on the fact that the milk's physical properties change, inducing different vibration responses at various stages of degradation.Using the Inception Time deep learning model, VibMilk achieves accuracy in detecting milk spoilage across 23 different stages, from fresh (pH = 6.6) to fully spoiled (pH = 4.4).
Problem identified from the existing system:

- This system follows vibration recognition at different stages which makes the system complex.
- Different smartphone models may have varying vibration motors and IMU sensor qualities, leading to inconsistent detection accuracy across devices.
- Users may need to position the smartphone in a particular way or follow certain steps, which could be inconvenient for everyday use.

Existing milk spoilage detection systems face several significant challenges that hinder their effectiveness and practicality. Many current methods rely on expensive, specialized sensors, such as pH, gas, or optical sensors, which are not only costly but also require regular calibration and maintenance. This makes these systems impractical for widespread use, especially in everyday settings like homes or small-scale dairy operations. Additionally, these systems often depend on specialized hardware, making them less accessible to the average consumer. Another major issue is the limited sensitivity of existing systems; many fail to detect the subtle physical changes in milk during its degradation, which means spoilage might go undetected until it is too late, leading to the waste of milk or the consumption of unsafe products. Furthermore, most systems only provide binary detection (fresh or spoiled), which offers little insight into the different stages of spoilage, reducing their ability to predict milk quality with precision. The lack of real-time detection capabilities also means there is often a delay between the actual spoilage and its detection, limiting the practical value of these systems. Additionally, the complexity of operation and interpretation of data in some systems requires users to have specialized knowledge, making them less user-friendly. Lastly, many of these systems are not integrated with commonly used devices like smartphones, which reduces their potential for mass adoption. VibMilk addresses these issues by utilizing the vibration motor and

IMU of smartphones, offering a cost-effective, accessible, and accurate method for detecting milk spoilage across multiple stages in real-time.

The Conclusion part of the existing system:

The existing system for milk spoilage detection primarily relies on traditional methods such as visual inspection, smell, taste, and chemical testing, which can be subjective, time-consuming, and often impractical for everyday consumers. Some advanced techniques, such as electronic noses and biosensors, offer more accurate detection but require specialized equipment, making them costly and inaccessible for general use. These methods also often lack real-time monitoring capabilities, limiting their effectiveness in practical scenarios. Additionally, most conventional approaches do not provide a detailed analysis of the milk's degradation stages, making it challenging to assess its quality precisely. Given these limitations, there is a need for a more accessible, efficient, and accurate solution to detect milk spoilage, which can be seamlessly integrated into daily life.

2.MAIN SECTION- II

2.1PROPOSED METHODOLOGY

The paper proposes Internet of Things (IoT) based solution for real-time raw milk quality and quantity parameters monitoring.

• We have implemented a Milk Spoilage Detection System using an ESP32 microcontroller interfaced with multiple sensors like temperature, pH, LDR and Vibration motor which analyses the quality of milk.

• Temperature sensor and pH Sensor probe has to be inserted in the milk sample to analyse the milk temperature and pH value.

• LDR stands for Low-Density Re (Light Dependent Resister). It has a variable register that changes depending on the amount of light. If the milk has a higher fat content, the sample scatters a large amount of light.

• Vibration motor is implemented to produce vibration during which the significant changes in fresh and spoiled milk is spotted.

• In case of any abnormalities, it is indicated using LED. Green represents the fresh milk, red represents adulterated. All these data are monitored via Blynk app using IOT technology

The proposed methodology introduces an IoT-based Milk Spoilage Detection System that enables real-time monitoring of raw milk quality and quantity using an ESP32 microcontroller integrated with multiple sensors. The system employs a temperature sensor and a pH sensor, both of which are inserted into the milk sample to assess its temperature and acidity level, key indicators of spoilage. Additionally, an LDR (Light Dependent Resistor) is used to analyze the milk's fat content based on light scattering properties. A vibration motor is incorporated to generate vibrations, allowing the system to detect significant physical changes between fresh and spoiled milk. In case of abnormalities, an LED indicator provides a visual alert—green for fresh milk and red for adulterated or spoiled milk. The collected data is transmitted and monitored via the Blynk app using IoT technology, enabling real-time tracking and ensuring efficient milk quality assessment.

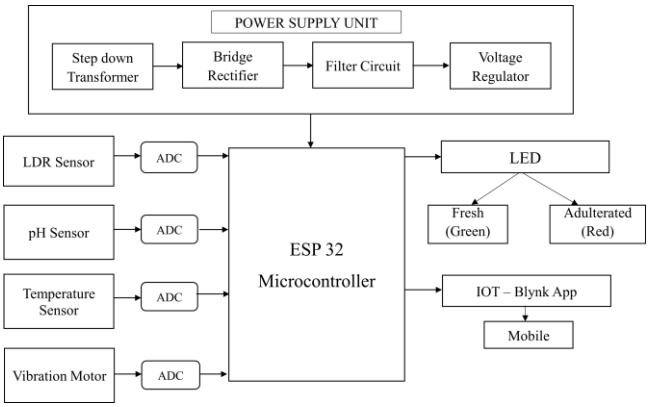

Fig 2.1: Block diagram of proposed system

IoT-Based Real-Time Milk Quality and Quantity Monitoring System using Blynk App

An IoT-Based Real-Time Milk Quality and Quantity Monitoring System using the Blynk app can help dairy farms and milk collection centers monitor milk parameters remotely. The system uses sensors**,** microcontroller and IoT platforms for real-time data collection, processing, and visualization.

- **Temperature and pH Analysis:** A temperature sensor and a pH sensor probe are inserted into the milk sample to measure its temperature and pH levels, which are key indicators of spoilage.
- **Fat Content Detection:** The LDR sensor, which has a variable resistor dependent on light intensity, analyzes milk fat content based on light scattering properties. A higher fat content results in greater light scattering.
- **Vibration-Based Spoilage Detection:** A vibration motor generates vibrations in the milk sample, allowing the system to detect significant changes in physical properties between fresh and spoiled milk.
- **Real-Time Abnormality Detection:** An LED indicator provides immediate visual feedback—**green** for fresh milk and **red** for adulterated or spoiled milk.

All collected data is monitored in real-time via the Blynk app using IoT technology, ensuring an efficient and automated approach to milk quality assessment. This system provides an accessible and accurate solution for detecting milk spoilage, reducing reliance on traditional methods such as smell and taste tests.

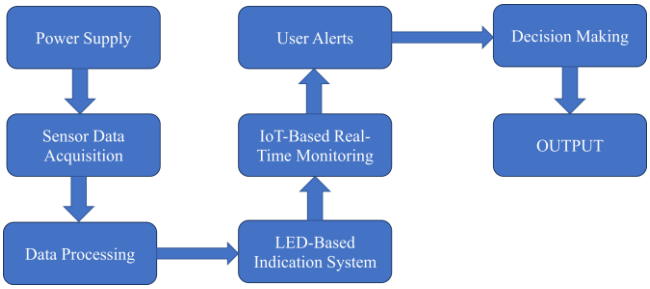

Fig 2.2 Methodology

2.2SYSTEM IMPLEMENTATION

(i) Hardware Requirement:

- Power supply
- ESP32 Controller
- Temperature sensor
- PH sensor
- LDR Sensor
- Vibration Motor

(ii) Software Requirement:

- Arduino IDE
- Embedded C

SOFTWARE RESULT:

The above results show the action of the Milk:

- When the Milk has high temperature, it shows the notification that: "Milk has High Temperature."
- When the milk has high fat content, the notification is sent: "Milk has Higher Fat Content."
- If there are any changes in the milk, it shows the notification that:"Milk has Too Impurity."

In this study, our primary aim is todevelop an efficient and real-time IoT-based solution for monitoring raw milk quality and quantity parameters.

- Temperature sensor and pH Sensor probe has to be inserted in the milk sample to analyze the milk temperature and pH value.
- LDR stands for Light Dependent Resister. It has a variable register that changes depending on the amount of light. If the milk has a higher fat content, the sample scatters a large amount of light.
- Vibration motor is implemented to produce vibration during which the significant changes in fresh and spoiled milk is spotted.

Fig 2.3 Blynk application result 1

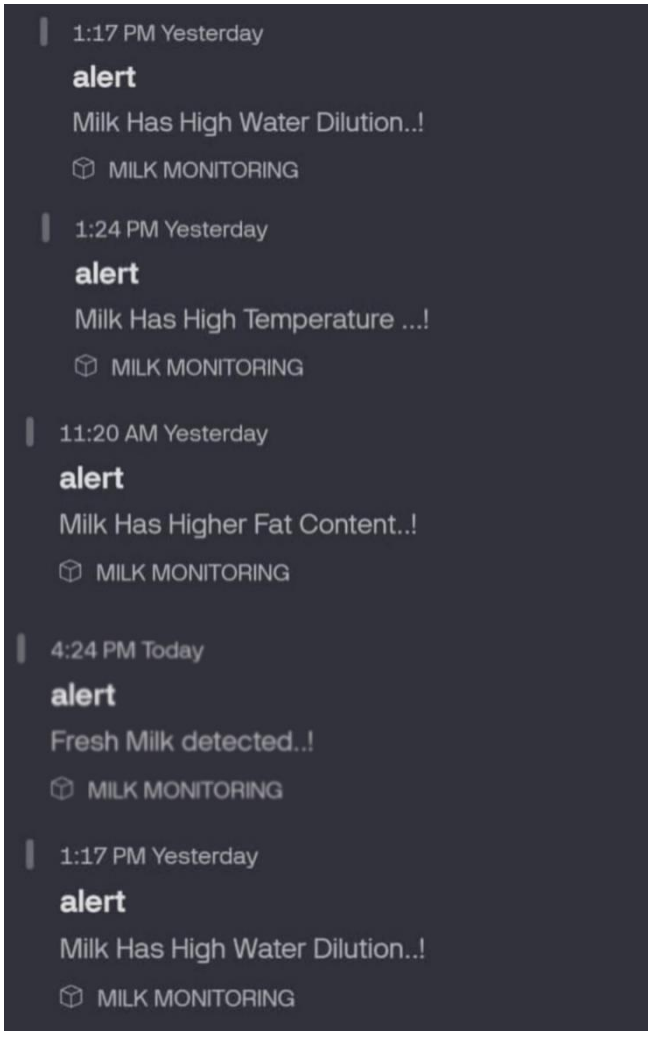

Fig 2.4 Blynk application result 2

3. HARDWARE RESULT

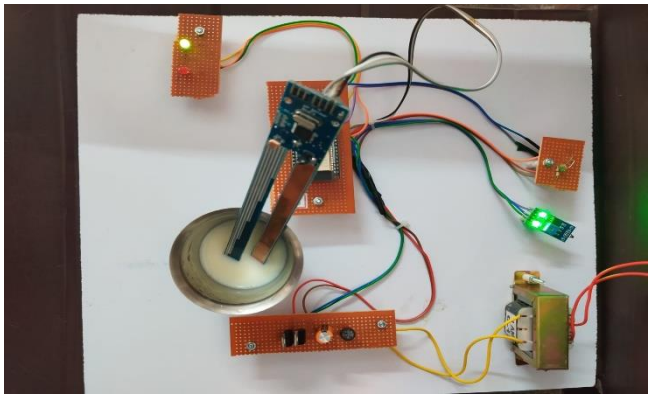

Fig 3.1 Fresh Milk Detection

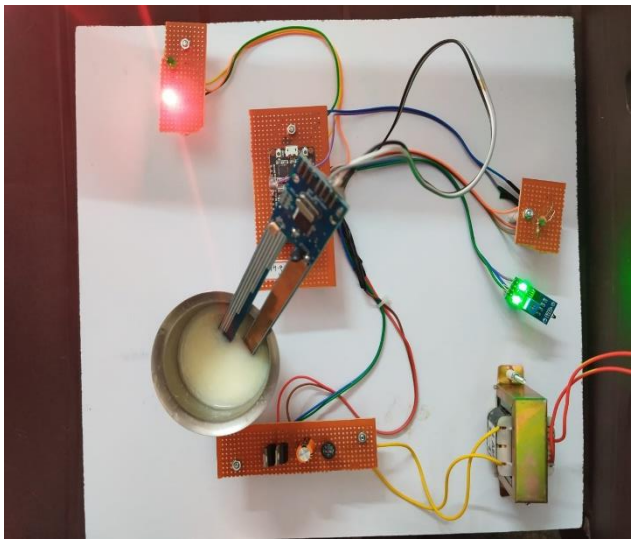

Fig 3.2 Spoiled Milk Detection

4.Conclusion

In conclusion, a smartphone-based vibration method for milk spoilage detection offers a non-invasive, efficient, and user-friendly solution for ensuring milk quality. By utilizing a smartphone's vibration motor and accelerometer, this approach detects changes in milk properties without direct contact, preserving hygiene and preventing contamination. The integration of machine learning algorithms enables real-time and accurate analysis, making it a cost-effective and accessible alternative to traditional testing methods. This technology benefits consumers, dairy producers, and retailers by providing instant feedback on milk freshness, reducing food waste and health risks. With further advancements, such as cloud-based monitoring and AI-powered predictive analytics, this method could revolutionize dairy quality control. Ultimately, this innovative solution enhances food safety, convenience, and sustainability in the dairy industry.

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