MILK QUALITY CHECKER

Aryan Rahul Patkar[1], Omkar Machindra Adak[2], Shreyash Gajanan kharade[3], Adinath Satpute[4]

[1,2,3,4] *Department of Electronics and Telecommunication, Samarth Polytechnic Belhe, Pune.*

Article Info	Abstract:
Article History: *Published:05 Feb 2026* *Publication Issue:* *Volume 3, Issue 2* *February-2026* *Page Number:* *66-71* *Corresponding Author:* *Aryan Rahul Patkar*	Milk is an essential nutritional food, yet its quality deteriorates rapidly due to microbial growth, improper storage, and intentional adulteration. Conventional laboratory-based milk testing techniques are accurate but time-consuming, expensive, and impractical for real-time field use. This project presents a sensor-based Milk Quality Checker designed to provide rapid, on-site evaluation of milk freshness and safety. The system integrates pH, temperature, and Total Dissolved Solids (TDS)/conductivity sensors with an ESP32 microcontroller to continuously monitor milk quality parameters. The collected data is processed in real time to identify spoilage trends and potential adulteration. The proposed solution is low-cost, portable, and suitable for deployment at dairy farms, collection centers, and distribution points, thereby enhancing food safety and quality assurance. *Keywords:* Milk Quality Monitoring, pH Measurement, Temperature Sensor, TDS Sensor, ESP32, Food Safety, Embedded System, IoT-Based Monitoring, Milk Spoilage Detection, Adulteration Analysis

1. Introduction

Milk plays a crucial role in human nutrition, supplying proteins, fats, vitamins, and minerals. However, due to its high water content and nutrient richness, milk is highly susceptible to microbial spoilage and adulteration. Factors such as improper refrigeration, extended storage time, and contamination significantly affect milk quality. Traditional milk testing methods, including titration, lactometer tests, and laboratory chemical analysis, require skilled personnel and specialized equipment.

To address these limitations, an automated Milk Quality Checker is proposed. By using sensors to measure critical parameters such as pH, temperature, and electrical conductivity, the system enables rapid, non-destructive testing of milk quality. The use of a microcontroller-based embedded system ensures portability, affordability, and real-time operation, making it suitable for on-site quality assessment.

2. Literature Survey

Recent research emphasizes the use of sensor technology and embedded systems for milk quality analysis. Studies show that pH variation is a strong indicator of milk spoilage due to lactic acid formation caused by bacterial activity. Conductivity-based techniques have been widely explored for detecting adulterants such as water, salt, and detergents.

Advancements in IoT-enabled systems allow real-time data transmission and remote monitoring of milk quality parameters. Several researchers have also implemented machine learning models to classify milk as fresh or spoiled using multi-sensor data. Compared to conventional laboratory methods, these approaches provide faster results, reduced operational cost, and suitability for field deployment..

Problem Statement

Existing milk quality testing techniques are largely laboratory-dependent, time-intensive, and unsuitable for continuous or on-site monitoring. There is a clear requirement for a compact, low-cost, and real-time system capable of detecting milk spoilage and adulteration early in the supply chain to ensure consumer safety and reduce economic losses.

Aim and Objectives

A To develop a portable and cost-effective milk quality monitoring system using sensors and an embedded controller.

Objectives:

- To measure milk pH, temperature, and TDS/conductivity accurately.
- To analyze sensor data to assess milk freshness and detect adulteration.
- To implement real-time data processing using an ESP32 microcontroller.
- To display milk quality status locally and support wireless data transmission.

System Architecture

T The proposed system consists of multiple sensors interfaced with an ESP32 microcontroller. The pH sensor measures acidity changes, the DS18B20 sensor monitors milk temperature, and the TDS sensor evaluates conductivity related to dissolved solids. Since high accuracy is required for analog signals, an external ADS1115 ADC is used.

The ESP32 processes the acquired data and determines milk quality based on predefined thresholds. The results are displayed on a 16×2 LCD and can also be transmitted wirelessly via

Wi-Fi or Bluetooth for remote monitoring and data logging.The ESP32 is a low-cost, low-power microcontroller with integrated Wi-Fi and Bluetooth capabilities, developed by Espressif Systems. It features a dual-core Tensilica LX6 processor, operates at up to 240 MHz, and supports a wide range of peripherals including ADC, DAC, SPI, I²C, UART, and PWM. Its built- in wireless modules make it ideal for IoT applications, including smart sensing, real-time data transmission, and remote monitoring**.**
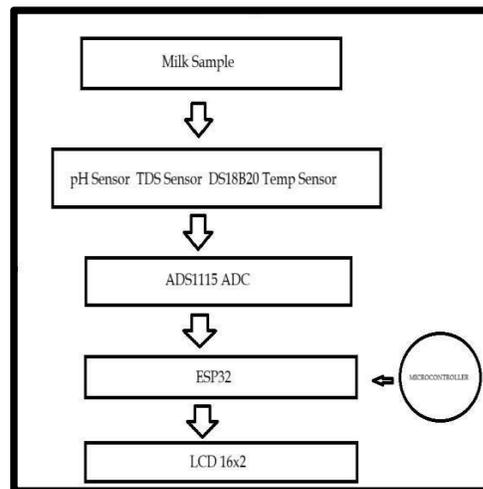
- **Gravity pH sensor**

- **Esp32**
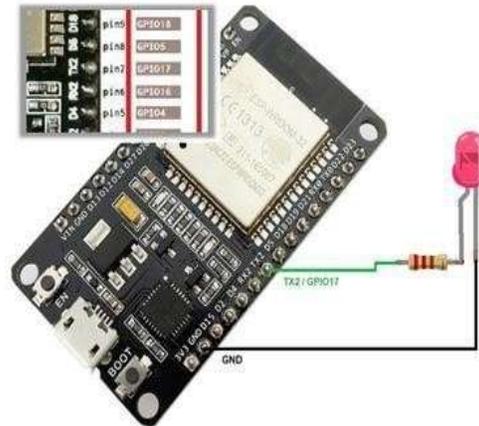
Components

The Gravity pH Sensor is an easy-to-use sensor module designed to measure the pH level (acidity or alkalinity) of liquids. It typically consists of a pH probe connected to an interface board that converts the analog signal into a readable output for microcontrollers like Arduino or ESP32. Widely used in water quality monitoring, agriculture, and food industry applications, it provides accurate real-time pH measurement

- **Gravity TDS sensor**

The Gravity TDS (Total Dissolved Solids) Sensor measures the concentration of dissolved solids in water or liquid solutions by detecting the electrical conductivity. It provides an analog output proportional to the TDS level, which helps assess water or liquid purity. Commonly used in water quality monitoring, agriculture, and food industry, it's compatible with microcontrollers

- **Water Proof Temperature DS18B20**

The DS18B20 is a digital temperature sensor with a waterproof stainless steel probe, ideal for measuring temperature in liquids. It uses the 1- Wire communication protocol, allowing multiple sensors to connect on a single data line. Known for its accuracy (±0.5℃) and ease of use with microcontrollers like Arduino and ESP32, it's widely used in environmental monitoring and food safety applications

- **ADC ADS1115**

Arduino and ESP32 for real-time measurement**.**
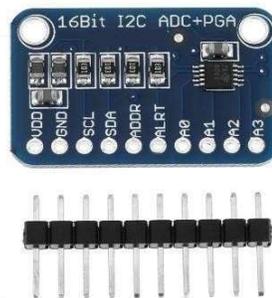
- **LCD Display 16X2**
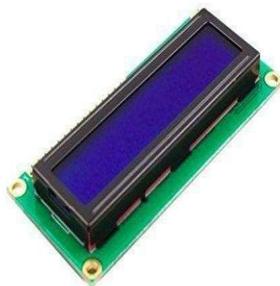
The 16x2 LCD is a commonly used alphanumeric display module that can show 16 characters per line on 2 lines. It uses the HD44780 controller and communicates via parallel or I²C interface. It's widely used in microcontroller projects for displaying data such as sensor readings, status messages, and user prompts.

4. Working

When milk is introduced to the system, sensors continuously monitor pH, temperature, and TDS levels. The ESP32 collects and processes this data, comparing it with standard acceptable ranges. If deviations are detected, the system classifies the milk as fresh, spoiled, or potentially adulterated. The results are displayed instantly and can be transmitted wirelessly for record keeping.

The ADS1115 is a 16-bit analog-to-digital converter (ADC) with an I²C interface. It offers high-resolution, low-noise measurements and includes four input channels, programmable gain amplifier (PGA), and a sample rate up to 860 samples per second. Widely used to enhance microcontroller ADC capabilities, it's ideal for precise sensor readings in applications like environmental monitoring and instrumentation.

5. Results

Experimental observations demonstrate that fresh milk maintains near-neutral pH, stable temperature, and normal TDS values. As milk spoils, pH decreases and conductivity increases due to bacterial activity. The system accurately detected these changes, validating its effectiveness for real-time milk quality monitoring.

Advantages & Applications Advantages

- Rapid and real-time milk quality assessment

- Portable and easy to operate

- Cost-effective compared to laboratory testing

  Applications

  - **Dairy farms and milk collection centers**

  - **Milk processing and packaging industries**

  - **Quality assurance during transportation and storage**

Future Scope

Future enhancements may include additional sensors for detecting specific adulterants, cloud- based data analytics, and machine learning algorithms for improved classification accuracy. Miniaturization and mass production can further reduce system cost and increase adoption.

6. Conclusion

The developed Milk Quality Checker provides an efficient, reliable, and economical solution for real-time milk quality assessment. By integrating sensor technology with an embedded IoT platform, the system helps ensure food safety, reduce spoilage losses, and improve consumer confidence..

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