TEAM NAME – **The Dev Dream**

Problem Statement Title -

"Developing an AI-driven, affordable, and portable milk quality testing solution for small-scale dairy farmers, enabling rapid, real-time assessments without reliance on traditional lab facilities. This project aims to tackle challenges in milk safety, quality consistency, and spoilage prediction, especially in rural areas where access to advanced testing is limited."

Theme - MedTech / Bio-Tech / Health-Tech

# MILK QUALITY ANALYSIS

## What is our Proposed Solution?

- Our AI-Powered, portable device leverages advanced sensors to monitor milk quality, freshness, and spoilage indicators in real time, specifically designed for small-scale dairy operations. The device integrates with cloud technology for instant data analysis, providing predictive insights and comprehensive quality reports. This solution ensures rapid, actionable feedback, enabling farmers to maintain high standards in milk safety and quality without needing traditional lab facilities.

## What are the Innovative ideas we have used?

- Predictive AI Models: Utilizes advanced machine learning algorithms to forecast spoilage and quality degradation based on environmental and historical data.
- Dual Mode Functionality: Operates seamlessly in both offline and online modes, providing instant quality insights on-device or through cloud connectivity.
- Blockchain Integration: Ensures traceability and transparency in milk quality data from farm to consumer, enhancing trust and accountability.

## How Big is Dairy Industry?

- Cattle population : **303 million**
- Indian dairy market : **₹355 crores**
- international exports : **₹4800 crores**
- Production Capacity : **210 million tonnes** of milk p.a.

## What are the problems we face today?

- Milk is a perishable product
- Traditional MBRT test : **8-10 hours** for results
- Difficulty in wide scale integration of the test

## How It Addresses the Problem ?

- **Real-time**, **faster** detection of spoilage
- **Multi-sensor** integration for more accuracy (color, pH, gas, and temperature).
- **Continuous monitoring** for proactive quality control.
- **Non-destructive** testing for larger batch quality checks.
- **Portable and scalable** solution, adaptable to various stages of the dairy supply chain.
- **Early detection** of spoilage for better **waste management** and **shelf life prediction**.

# TECHNICAL APPROACH

**ESP32 micro controller** is turned ON

**Milk Sample** is inserted

**MQ-4**, **pH**, **Ultrasonic**, **Temperature**, **Colorimetric** sensors are activated

**DATA ACQUISITION**

**Methane** levels are measured using **MQ-4 sensor**

The **concentration** of milk is calculated using data from the **Ultrasonic Sensor**

The intensity of **Red**, **Green & Blue** light is analysed using the **TCS3200 sensor**

**pH level** is determined using the **pH sensor**

**Temperature** is measured with the **DS18B20 sensor**

**Data Transmission using ThingSpeak cloud API**

The dataset is analyzed using **AI tools** to accurately predict **milk's quality**

The data is then imported and **analysed** in **MATLAB.**

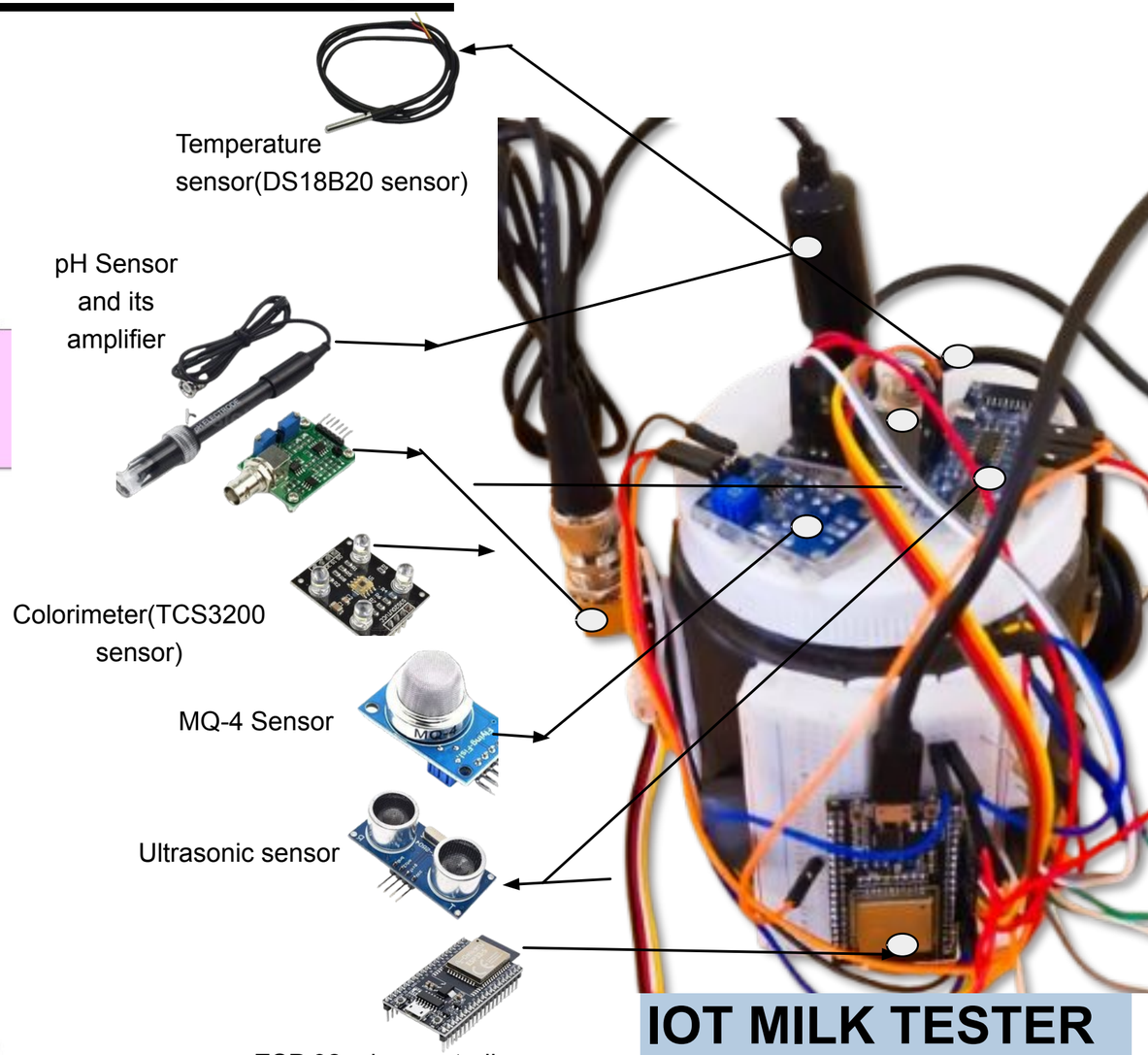
The sensor data is **visualized** in **graphical form**

**FINAL OUTPUT**

**Voice Assistant Integration:** Ai tool on our device's feedback speaker will give detailed report of milk

**Online Mode:** detailed chemical analysis of milk will be displayed on our website/app.

**Offline Mode:**LCD display on the device will show milk freshness percentage




**IOT MILK TESTER [Our Prototype]**

# Artificial Intelligence Implementation

**1. Data Collection and Preprocessing**

Sensors capture data on pH, temperature, gas emissions, and color metrics in real-time.

Data is cleansed and normalized to improve prediction accuracy and machine learning model performance.

**2. Machine Learning Models**

Classification Model: Classifies milk quality into categories (e.g., Fresh, Degrading, Spoiled) based on real-time sensor data.

Regression Model: Predicts spoilage time and remaining freshness to help manage supply chain logistics.

**3. Predictive Analysis**

- Input Layer: Accepts raw sensor data.
- Feature Extraction Layers (Hidden Layers 1 & 2): Captures complex relationships in the data, identifying significant patterns indicative of milk quality.
- Sequential Data Layer (LSTM/GRU): Adds the ability to handle time-sequenced data, predicting trends in spoilage over time.
- Dropout Layer: Reduces overfitting by randomly dropping units, enhancing the model's robustness.
- Output Layer: Produces a final prediction—either a classification of milk quality or a freshness score for logistic planning.

**Training the Model**

Data Collection: Collected sensor data is split into training, validation, and testing sets.

Loss Function: For classification, cross-entropy loss is used; for regression, mean squared error (MSE) is appropriate.

Optimization: Gradient descent with an adaptive algorithm like Adam, optimizing the model by minimizing the loss function over time.

**4. Blockchain-Enabled Traceability**

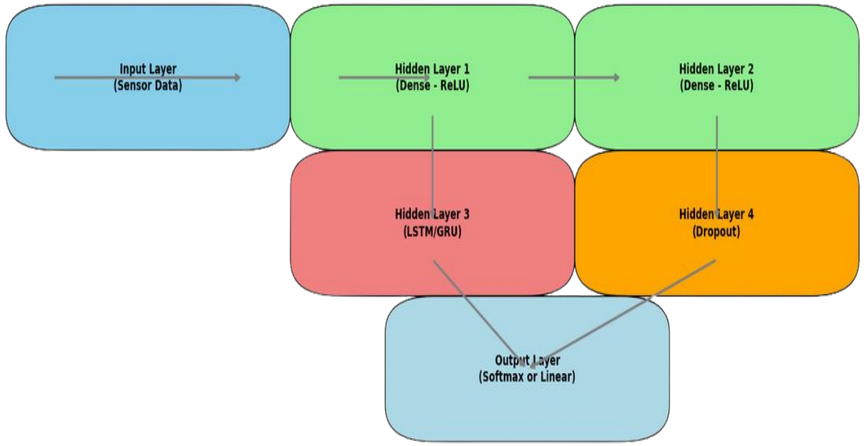
- Secure and transparent record of milk quality data from farm to distribution.
- Builds trust by ensuring data immutability and visibility for consumers.

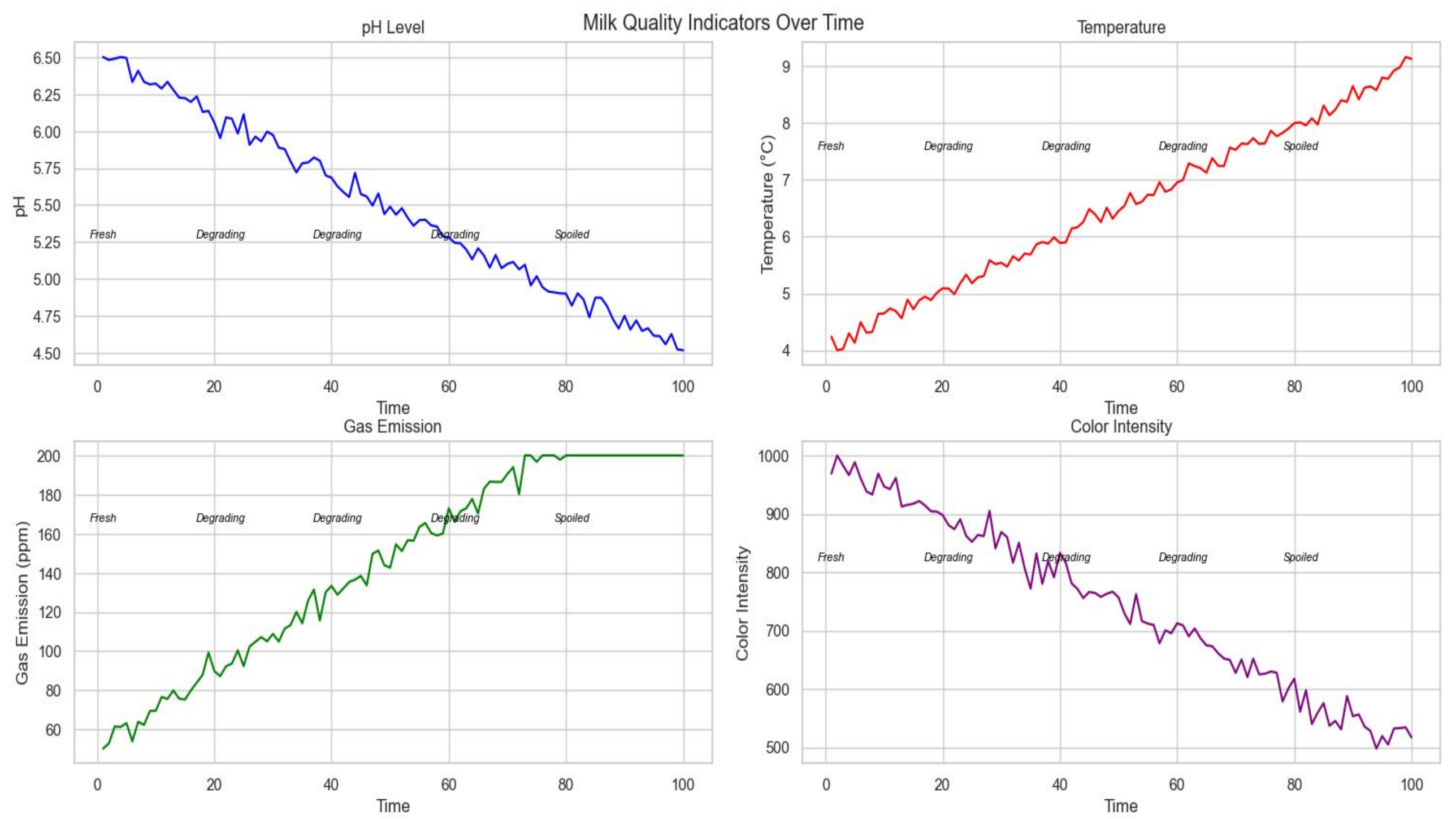
**5. Insights and Decision Support**

- AI generates actionable insights on milk quality, accessible through a mobile dashboard.
- Offers practical guidance based on environmental factors and seasonal trends to optimize dairy production.

**6. Continuous Learning and Model Improvement**

- The system adapts to new data, enhancing accuracy over time.
- Feedback loops from user interactions improve model recommendations for long-term use.




Milk Quality Indicators Over Time
pH Level
pH
Time
Fresh
Degrading
Degrading
Degrading
Spoiled
Temperature
Temperature (°C)
Time
Fresh
Degrading
Degrading
Degrading
Spoiled
Gas Emission
Gas Emission (ppm)
Time
Fresh
Degrading
Degrading
Degrading
Spoiled
Color Intensity
Color Intensity
Time
Fresh
Degrading
Degrading
Degrading
Spoiled

# FEASIBILITY AND VIABILITY

TARGET MARKET:

- Milk processing plants at the industrial level.
- Monitors and reports on various chemicals and nutrients present in milk via multi-sensors.

**TARGET MARKETS:**

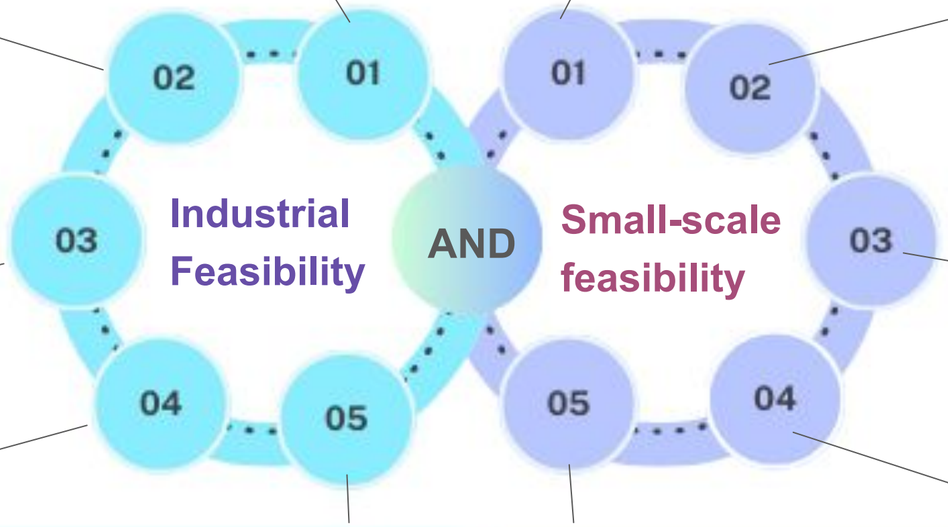
Dairy farmers and small milk collection centers.

INNOVATION TECH:

- **Use of Drone technology :** for monitoring industrial chimneys and analyzing gas concentrations, aiding in milk quality assessment and machine feasibility.

DEVICE DETAILS:

Data if colorimetric sensor is transmitted to a centralized server.




COST:

**device cost-₹8,000 to ₹10,000** per unit to implement on large-scale.

COST:

**Device cost-₹200 to ₹300** per unit for small-scale implementation.

OUTPUT & ANALYSIS:

- A detailed solution-oriented report based on sensor data, providing guidelines to improve production quality.
- Machine learning algorithms will be used to process data and optimize milk processing.

DATA COLLECTION METHODS:

The system will use a large dataset of milk quality readings from different regions and breeds of India.

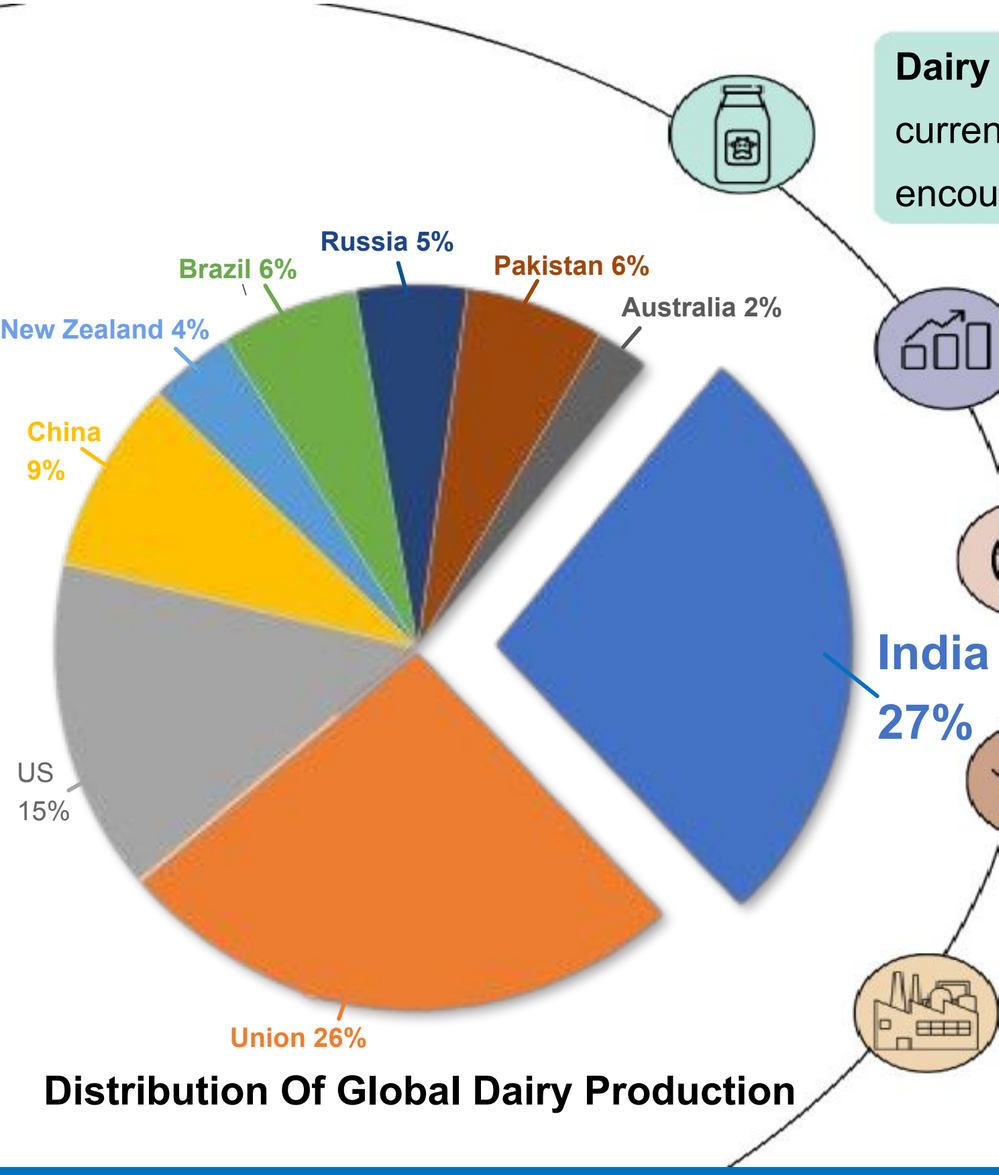
ANALYSIS:

Gives detailed reports on milk freshness , quality, nutrient composition and enables farmers to monitor and improve milk quality.

OUTPUT:

- 16x2 display on the device shows milk freshness on a scale of 0-100%
- Results can be viewed on Mobile phone in real-time data

# IMPACT AND BENEFITS




**Distribution Of Global Dairy Production**

**Dairy Farmers & Distributors:** Increase India's export of dairy products to **30%** from the current **25%**, globally. Boost profits for dairy farmers by approximately **1.5 times**, encouraging more participation in the industry.

**Dairy Industry:** Increase the dairy industry's contribution to the **national economy** from **5% to 7%**. Accelerate the growth rate of milk production, currently at a **CAGR** of **6.1%**.

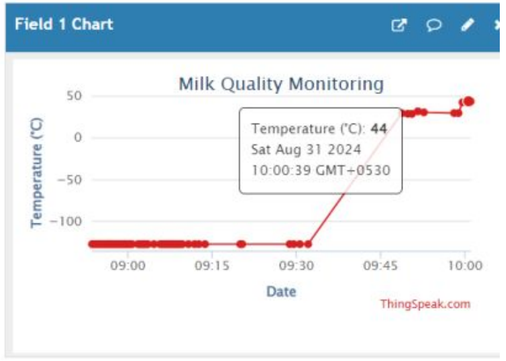
**Environmental Benefits:** Decrease reliance on harmful chemicals and mitigate the production of **leuco-methylene blue** in the MBRT test, which can cause **serotonin toxicity** in humans and pose threats to aquatic life.

**Social Benefits:** Reduce the circulation of unsafe milk, which currently accounts for **0.18%** of all milk produced. Incentivize investments by individual entrepreneurs in the dairy sector.

**Other industries:** Can be adapted for determining quality in the **food and beverage industry** and **chemical industries** by observing pH, temperature, gas emissions, and chemical levels for safety and quality. Can be used by the **Central Pollution Control Board** and the **Food Safety and Standards Authority of India**.

# RESEARCH AND REFERENCES

**1. FRESH BOILED TONED MILK (60 C)**

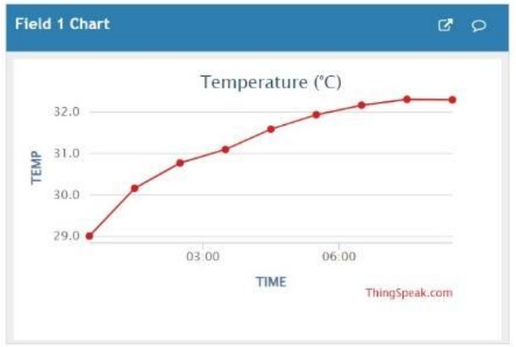


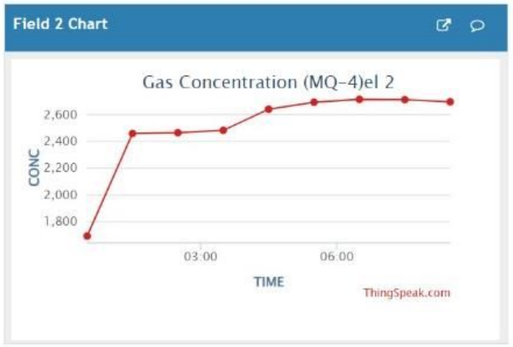


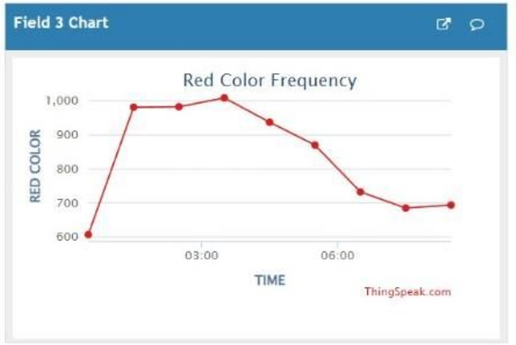


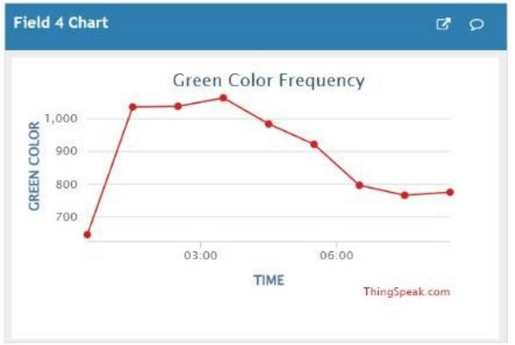


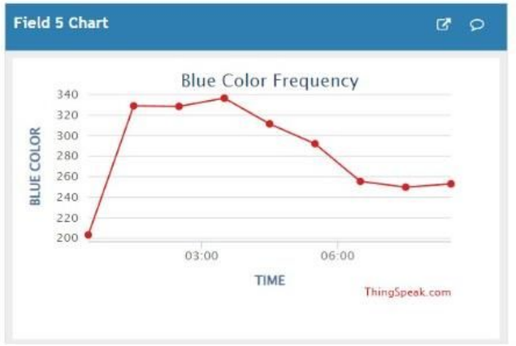
**2. SPOILED TONNED MILK**




# RESEARCH AND REFERENCES

**Temperature Sensor (Field1):**

- Fresh Boiled Toned Milk at 60°C: High temperature readings reflect the boiling process, confirming the milk's freshness and recent boiling.
- Spoiled Milk at Room Temperature: Lower temperature readings align with room temperature, indicating the milk was left out overnight and may be spoiled.

**MQ4 Sensor (Field2):**

- Fresh Boiled Toned Milk: Lower MQ4 readings suggest that boiling has reduced volatile compounds, likely due to the removal or alteration of gases.
- Spoiled Milk: Higher MQ4 readings point to increased volatile compounds, likely resulting from bacterial activity during spoilage, indicating chemical changes.

**Colorimeter (Field3 & Field4):**

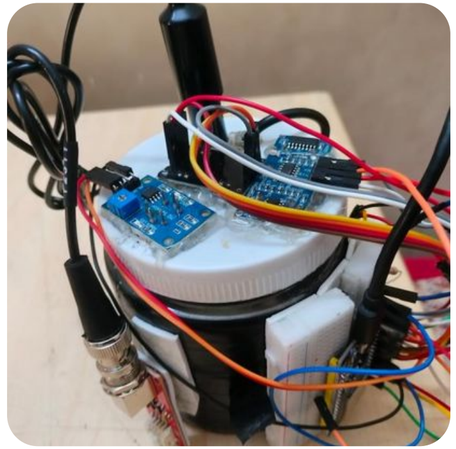
- Fresh Boiled Toned Milk: Higher colorimeter values indicate the milk's color and consistency remained stable after boiling, possibly enhanced or preserved by the boiling process.
- Spoiled Milk: Lower colorimeter values suggest color changes, likely from protein breakdown and other spoilage-related transformations.

**Density:**

- Fresh Boiled Toned Milk: Higher density reflects the concentration effect of boiling, reducing water content and increasing milk thickness.
- Spoiled Milk: Lower density suggests breakdown of milk solids, resulting in a thinner consistency as spoilage progresses.

**Logical Interpretation:**

- Fresh Boiled Toned Milk: The combination of high temperature, elevated colorimeter values, low MQ4 readings, and higher density indicates freshness and quality retention post-boiling, with boiling concentrating the milk.
- Spoiled Milk: Lower temperature, higher MQ4 values, reduced colorimeter readings, and lower density clearly signal spoilage, reflecting the breakdown of the milk's chemical and physical properties over time.




1. Fssai research on milk quality : https://bit.ly/4evey4t
2. Fssai guidelines for milk testing : https://bit.ly/3XxcKAU
3. DAHD Report : https://bit.ly/4ecrH2v


1. Our Prototype Sample test video : https://youtu.be/Gj1L0_OP2Zk
2. Our Github Repository link : https://github.com/debadutta1209/milk_quality_analysis_sih.git