Monthly Internship Report - October 2025

Project - Smart Controller for Heat Pump Dryer

Sujit Laware
Intern, RuTAG IIT Madras

October 2025

1. Executive Summary

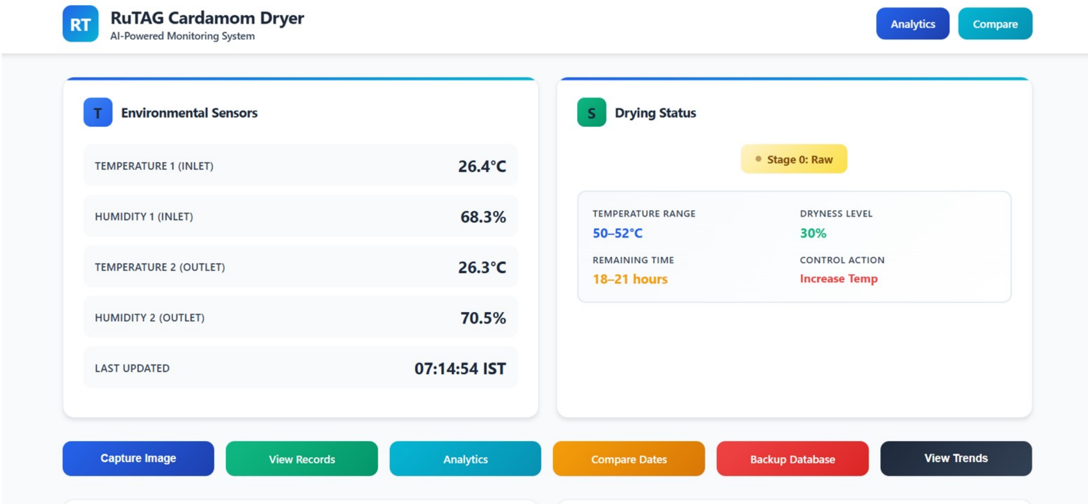

Figure 1: Complete System Overview of Smart Controller for Heat Pump Dryer

During October 2025, significant progress was made in developing the AI-Powered Real-Time Sensor Monitoring System for Heat Pump Dryer at RuTAG, IIT Madras. This month's work focused on implementing a comprehensive dashboard system that integrates real-time environmental sensing with AI-based visual assessment for complete process control of the cardamom drying operation.

The primary progress includes the development of a multi-featured monitoring dashboard, integration of dual temperature and humidity sensors, implementation of historical data logging and analytics, and refinement of the AI model's stage classification system with evidence-based temperature control parameters.

2. October 2025 Work Overview

2.1 Project Context

The Smart Controller for Heat Pump Dryer project aims to revolutionize agricultural processing by combining computer vision, IoT sensors, and intelligent control systems. October's deliverables focused on creating a production-ready monitoring and control interface that provides operators with complete visibility and control over the drying process.

2.2 Monthly Objectives

The key objectives for October 2025 were:

- Design and implement a comprehensive monitoring dashboard
- Integrate real-time environmental sensing capabilities
- Develop historical data logging and analytics features
- Create comparative analysis tools for process optimization
- Refine AI model integration with evidence-based control parameters
- Implement visual tracking of drying stages

3. System Architecture Development

3.1 Comprehensive Dashboard System

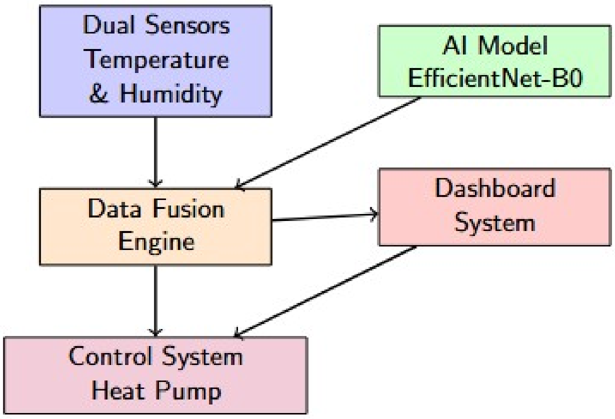

Figure 2: Dashboard System Architecture and Component Layout

The centerpiece of October's development was the implementation of a multi-panel dashboard system that provides complete process visibility and control.

3.1.1 Dashboard Components

The dashboard architecture consists of three primary components:

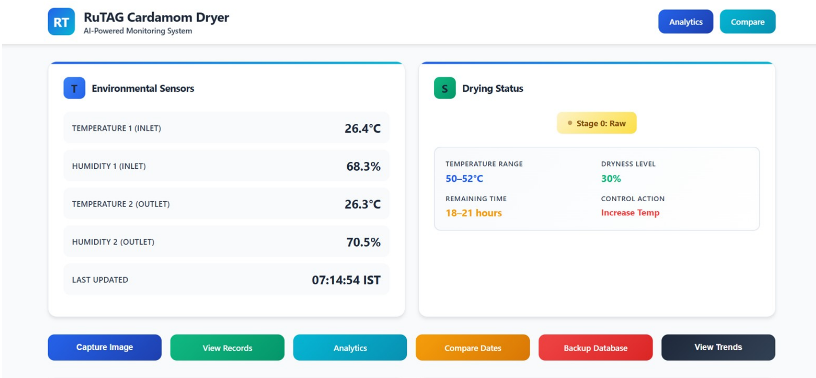

Figure 3: Dashboard System Architecture and Component Layout

1. **Environmental Monitoring Dashboard**

- Real-time display of inlet and outlet temperature readings
- Live humidity monitoring for both inlet and outlet
- Continuous data updates with minimal latency
- Drying status display showing current stage
- Target temperature range indicators
- Drying level percentage visualization
- Recommended control action display

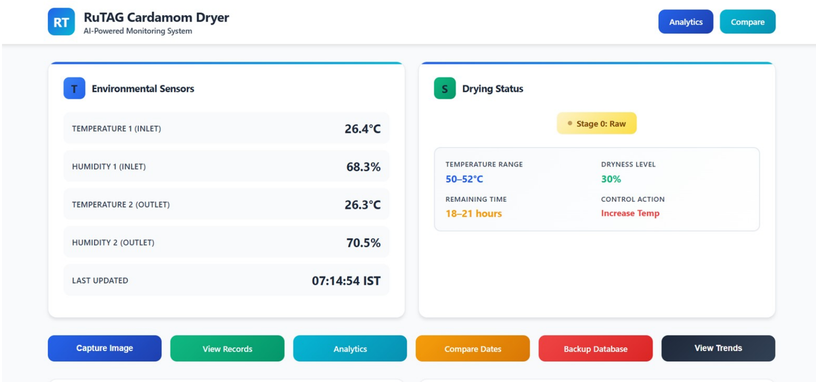

Figure 4: Dashboard System Architecture and Component Layout

2. **Visual & Performance Analysis Panel**
   - Latest captured image of cardamom for visual tracking
   - Real-time performance trends graph (Temperature vs. Humidity)
   - Time-series visualization of environmental conditions
   - Quick analysis and comparison capabilities
   - Visual correlation between sensor readings and drying progress

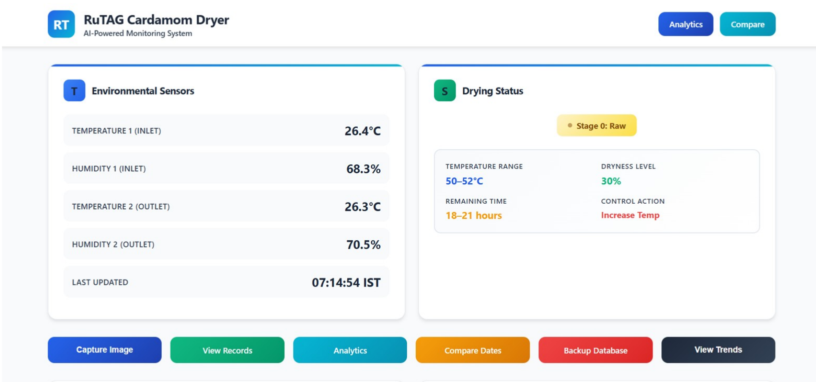

Figure 5: Dashboard System Architecture and Component Layout

3. **Historical Analytics Dashboard**
   - Comprehensive historical log of drying records
   - Timestamp-based record management
   - Detailed parameter logging for each drying session
   - Download and export functionality for reports
   - Record deletion and management tools
   - Date-wise comparison features

3.2 Real-Time Environmental Sensing Integration

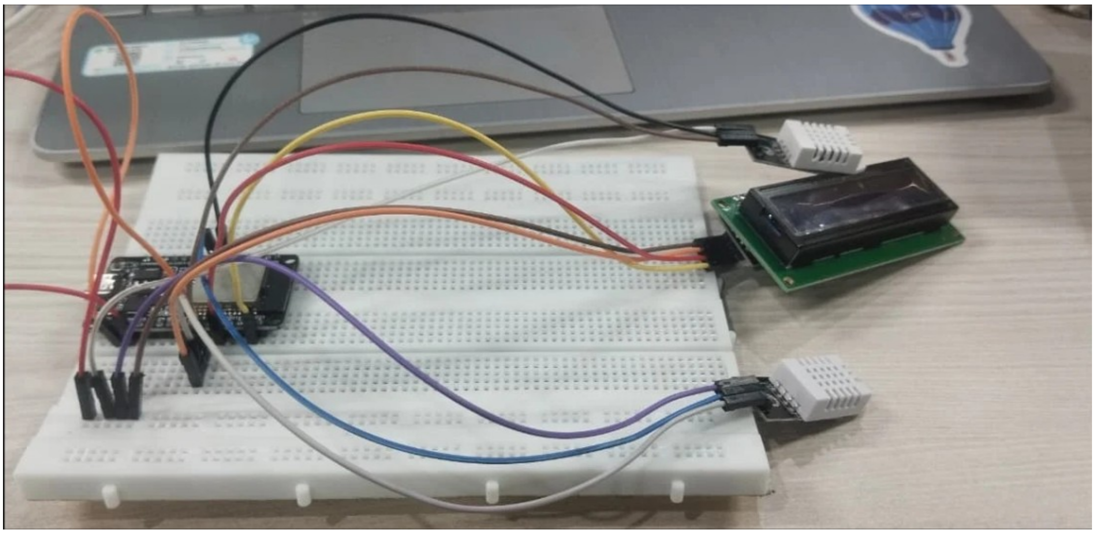

Figure 6: Sensor Installation and Configuration in Heat Pump Dryer

A critical progree in October was the integration of high-precision dual sensor systems for comprehensive environmental monitoring.

- **Dual Sensor Configuration**: Implemented high-precision temperature and humidity sensors
- **Inlet & Outlet Tracking**: Configured sensors to measure both inlet and outlet conditions
- **Moisture Removal Efficiency**: Calculated efficiency metrics based on inlet-outlet differentials
- **Live Display System**: Integrated on-site LCD for instant readings accessible to operators
- **Data Synchronization**: Ensured real-time synchronization between sensors and dashboard

4. AI Model Integration and Refinement

4.1 Enhanced Visual Assessment System

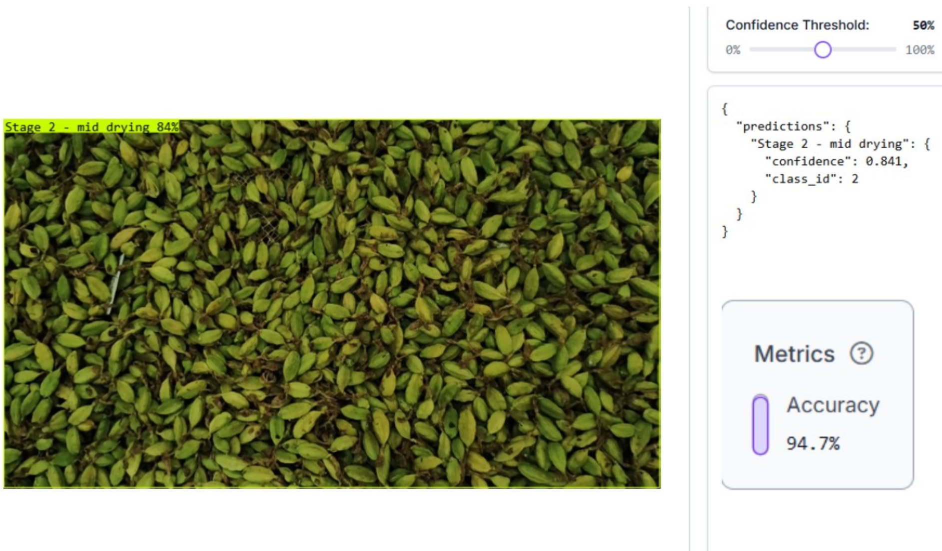

Figure 7: AI Model Training Process and Performance Metrics

October's work included significant refinements to the AI model integration for visual drying assessment.

4.1.1 Model Training Enhancement

- **Robust Dataset Creation**: Combined on-site captured images with curated online datasets
- **Expert Labeling**: Implemented systematic labeling protocol for drying stages
- **Training Optimization**: Fine-tuned model parameters for improved stage classification
- **Visual Quality Assessment**: Enhanced model's ability to assess product quality indicators

5. Advanced Analytics Features

5.1 Historical Data Management

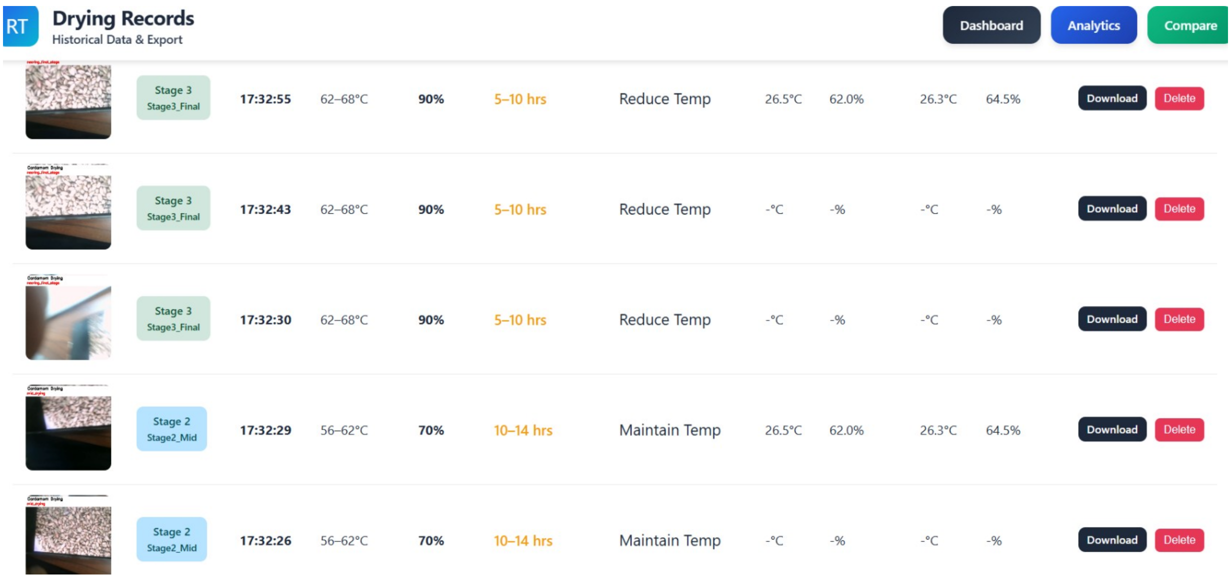

Figure 8: Data Logging System Architecture and Storage

October's development included comprehensive historical data management capabilities.

5.1.1 Data Logging System

- **Automated Recording**: Every drying session automatically logged with timestamp
- **Parameter Capture**: Complete capture of temperature, humidity, stage, and AI confidence
- **Image Archival**: Storage of captured images linked to each record
- **Metadata Integration**: Additional context including batch information and operator notes

5.1.2 Comparative Analysis Tools

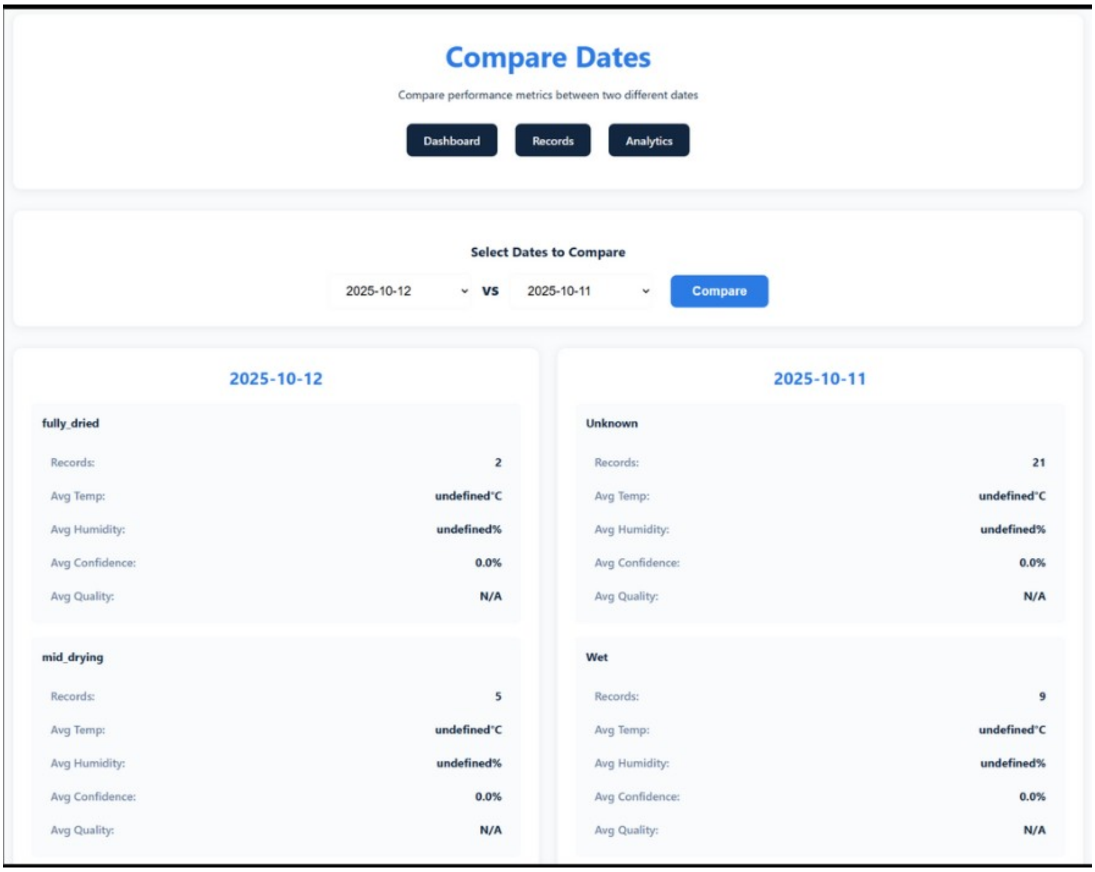

Figure 9: Date-wise Comparative Analysis Interface

A powerful date-wise comparison feature was implemented to enable:

- Side-by-side comparison of drying performance between dates
- Trend analysis for process optimization
- Identification of optimal drying parameters
- Quality control through batch comparison
- Performance benchmarking across different conditions

5.2 Analytics Dashboard

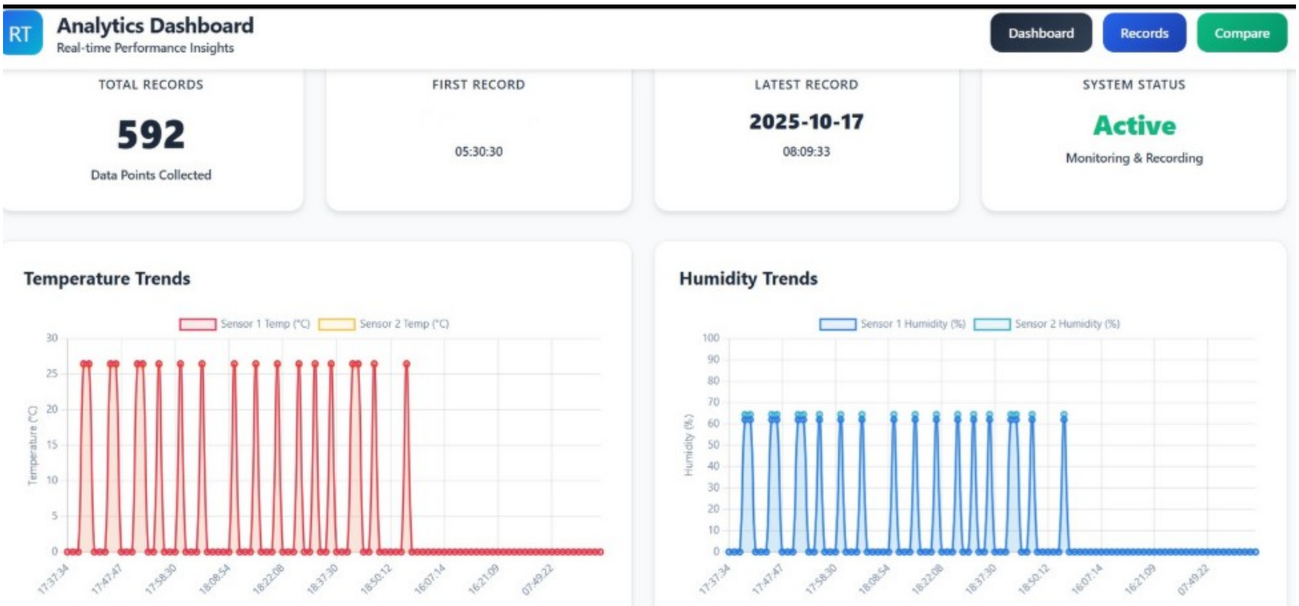

Figure 10: Complete Analytics Dashboard with Performance Metrics

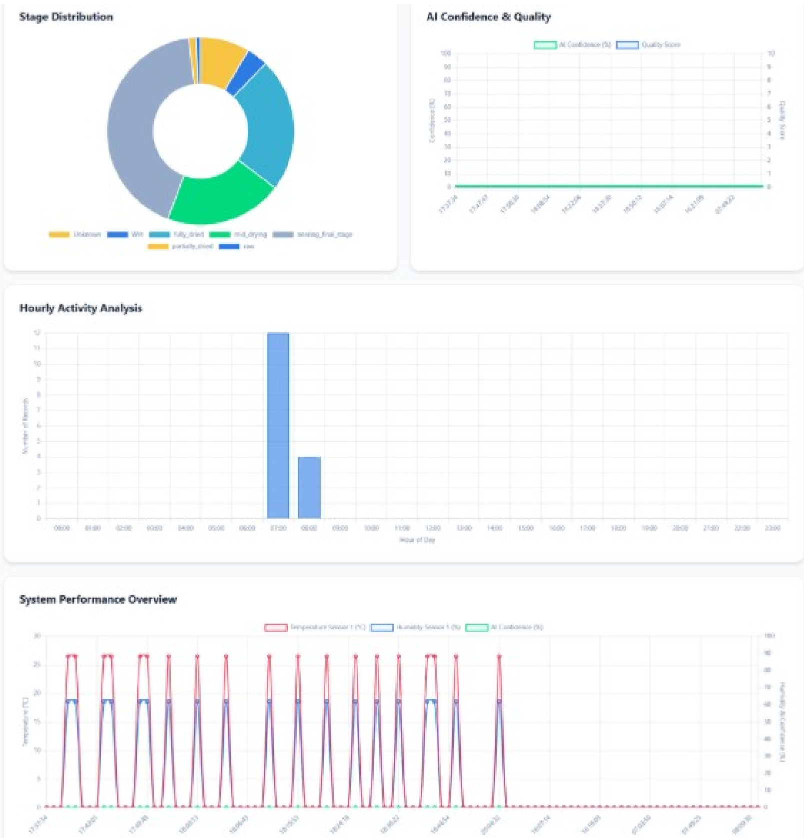

Figure 11: Complete Analytics Dashboard with Performance Metrics

Two-level analytics capabilities were developed:

5.2.1 High-Level Dashboard

- Total records and system status display

- Live graphs tracking temperature and humidity trends
- Quick access to key performance indicators
- System health monitoring

5.2.2 Detailed Analytics View

- Stage distribution charts showing time spent in each drying stage
- Hourly activity patterns for process optimization
- AI performance scores and confidence metrics
- Correlation analysis between sensor data and AI predictions
- Quality scores derived from combined sensor and visual data
- Full system overview with integrated insights

October 2025 progress in the Smart Controller for Heat Pump Dryer project. The implementation of a comprehensive monitoring and analytics dashboard, integration of real-time environmental sensing, and development of evidence-based control parameters have transformed the system into a production-ready solution.

The combination of AI-powered visual assessment, precision sensor monitoring, and intelligent analytics provides operators with unprecedented visibility and control over the cardamom drying process. The evidence-based approach ensures that control decisions are grounded in scientific research, optimizing both quality and efficiency.