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Smart Food Safety Complaint and Food Adulteration Platform with a Proposed IoT Extension for Cooking-Oil Monitoring

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Abstract: *This paper presents the Smart Food Safety Complaint and Food Adulteration Platform, a full-stack web application for accessible reporting and permissioned review of food-safety concerns, together with a proposed Internet of Things (IoT) extension for experimental cooking-oil monitoring. Citizens may not know a vendor's name, registration number or exact address, and long web forms can discourage them from reporting. Authorities, in turn, need controlled access, traceable review and prioritization of reports that are not automatically confirmed violations. The implemented platform addresses these needs through a guided multilingual complaint form with voice and location alternatives, role-based Admin and Authority workflows, educational adulteration guidance, and advisory analytics.*

The implemented system uses React with Vite on the client, Node.js with Express for REST services, and MySQL with Sequelize for persistence. Customers can submit and privately track complaints in English, Hindi or Marathi, optionally attaching evidence and a GPS or map-pin location. Admin and Authority users work in separate permissioned workspaces. Rule-based complaint risk scores, Jaccard-based duplicate matching and a privacy-aware hotspot grid assist human reviewers; they are not calibrated probabilities, and no trained deep-learning inference is claimed.

A separate, proposed research module uses an ESP32 microcontroller, an FDC1004 capacitance-to-digital converter, a custom capacitive probe and a DS18B20 temperature sensor to record the capacitance and temperature of controlled cooking-oil samples and send them to the same backend. Capacitance is treated as an electrical quantity; estimation of total polar compounds (TPC) is considered only after independent reference calibration and validation on held-out oil batches. The proposed device has not yet been built or validated, and no sensor accuracy is reported.

Developers report that 289 of 289 automated checks passed in Phase 6.1 of the web platform; these totals were not independently rerun for this paper. The platform is an independent academic implementation, notan official FSSAI service, and it does not replace accredited laboratory testing. The contribution is an integrated reporting-and-review design, a privacy-conscious advisory layer, and a reproducible protocol for future IoT validation.

Keywords: Food Safety, Food Adulteration, Complaint Management, Role-Based Access Control, React, Node.js, MySQL, Multilingual Interface, Cooking Oil, Capacitive Sensing, ESP32, FDC1004, Internet of Things.

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1. INTRODUCTION

Food safety is a public-health concern in which consumers are often the first to notice a problem, such as an unusual taste, a spoiled product or an unhygienic premises. Official channels such as the FSSAI Food Safety Connect platform [1] exist for lodging concerns, and the FSSAI Detect Adulteration with Rapid Test (DART) resource [2] offers simple household observations. The legal basis for food-safety regulation in India is the Food Safety and Standards Act, 2006 [3]. Even so, a citizen reporting a concern may not know the vendor's name, registration number or exact address, and long web forms can discourage completion.

Receiving a report is only the first step. A complaint needs controlled access, traceable review and prioritization by administrators and enforcement authorities, and a user report is not an automatically confirmed violation. Handling complaints through informal channels makes it difficult to preserve ownership, privacy, evidence and case history. Role-based access control [4], authenticated APIs [5], [6] and server-side privacy rules are therefore central design requirements rather than optional additions.

A second, distinct challenge concerns measurement. Repeated frying degrades cooking oil, and reliable assessment requires appropriate reference measures; visual appearance alone is insufficient. Regulatory guidance for used cooking oil is expressed through total polar compounds [7], and electrical sensing of oil has been studied as a possible route to rapid assessment [8], [9]. Reporting and measurement are therefore connected but different problems, and they should not be conflated.

The platform presented here has two components. The implemented component is a React/Vite, Express and Sequelize/MySQL web application with Customer, Admin and Authority workflows. The proposed component is an experimental ESP32 and FDC1004 cooking-oil sensing node. This status distinction is maintained throughout the paper: implementation evidence is not evidence of a validated laboratory-grade oil-quality instrument.

Reporting, Response and Measurement Barriers:

The reporting barrier arises when users lack the details that formal forms demand. A person who bought a food item from an unfamiliar roadside seller may remember only a landmark. Forms that insist on a registered business name or exact address exclude such reports, and online reporting in a single language limits participation. Prior work shows that unreported foodborne illness can be found in informal public data such as online reviews [10] and social-media signals [11], which suggests that users do describe problems when the reporting route is easy.

The response barrier arises after submission. Complaints contain personal and location information and may include photographs, so access must be limited to authorized roles, and each customer must be able to track only his or her own complaint. Reviewers also need help ordering large queues, while avoiding any impression that a computed score is a regulatory finding. The measurement barrier arises when oil quality is in question: a visual impression is not a substitute for reference measurement, and a sensor reading is not a quality verdict until it has been calibrated against one.

The research problem is therefore to make reporting accessible and to explore an accountable path from citizen reports to measured evidence. The platform answers the first part with an implemented web application. The second part, a path to measured oil evidence, is addressed only as a proposed and testable engineering design.

Digital Grievance Systems and Educational Adulteration Screening:

FSSAI Food Safety Connect is an existing official complaint channel [1]. The platform described here is an independent academic implementation and makes no claim of official affiliation. Its contribution lies in the integration of an easy guided form, optional unlisted-seller details, language and voice support, map alternatives, role-based case workflows and advisory analytics in one application.

The adulteration-screening feature is educational. It lets a user select a food item or issue category, view predefined possible concerns and DART-style observations [2], and then optionally attach evidence and open a complaint. It does not confirm chemical composition, does not certify the safety of a sample, and cannot replace accredited testing. Reviews of adulteration sources and detection methods [12] show that confirmation generally requires analytical methods beyond visual inspection.

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Earlier versions of the project code did not run trained image inference on uploaded photographs, and the platform therefore makes no claim of automated visual detection of adulterants. Educational guidance, complaint capture and human review are the implemented elements; any future image-analysis component would require its own dataset, training and independent validation.

Core Features and Techniques Used in the Platform:

- **FoodSafe Easy Reporting** – A guided four-step complaint form with progressive disclosure, clear prompts and a review stage before submission.
- **Multilingual and Voice Input** – English, Hindi and Marathi interface dictionaries with editable speech-to-text input using the browser Web Speech API [13], whose support is browser-dependent.
- **Location Alternatives** – Browser geolocation [14], a draggable map pin using Leaflet [15], and a manual address or landmark, so that a denied permission does not block reporting.
- **Role-Based Case Workflows** – Separate Customer, Admin and Authority workspaces with complaint ownership checks, private evidence review and case-action history.
- **Advisory Intelligence** – Rule-based complaint risk, Jaccard-based possible-duplicate matching and a privacy-aware hotspot grid that support, but do not replace, human decisions.
- **Proposed IoT Oil Monitoring** – An ESP32, FDC1004 and custom capacitive probe node for capacitance and temperature capture, with reference-based calibration to be performed before any TPC estimate is reported.

II. RELATED WORK AND LITERATURE REVIEW

Research on digital food-safety reporting and surveillance has examined how public information can reveal problems that formal systems miss. Harrison et al. [10] analysed online restaurant reviews to identify unreported foodborne illness in New York City, and Sadilek et al. [11] described machine-learned detection of foodborne illness at scale from user-generated signals. These studies establish the value of citizen-originated information, while FSSAI Food Safety Connect [1] provides the official complaint route in India under the Food Safety and Standards Act [3]. They also show that signals are leads for investigation, not confirmed violations.

Awareness of adulteration is supported by public education and review literature. Bansal et al. [12] summarize sources, health risks and detection methods of food adulteration, and the FSSAI DART resource [2] describes simple observations that households may use as an initial indication. These resources motivate an educational screening feature, while emphasizing that confirmation needs appropriate analytical methods and that photograph-based or observation-based screening is not certified detection.

The design of web systems for sensitive reports draws on established architectural and security concepts. Fielding [16] described the REST architectural style, on which Express-based APIs commonly rely [17]. Role-based access control models [4] define permissions by role, and JSON Web Tokens [5] provide a compact token format for authenticated requests. The OWASP API Security Top 10 [6] lists common API risks such as broken object-level authorization, which is directly relevant to complaint ownership. For aggregated location output, k-anonymity [18] motivates suppressing small groups, and the Jaccard coefficient [19] provides a simple set-overlap measure for comparing textual descriptions.

Accessibility and usability concerns shape the user interface. The Web Content Accessibility Guidelines [20] describe principles for perceivable, operable, understandable and robust content. Browser capabilities such as the Web Speech API [13] and the Geolocation API [14] can lower the effort of reporting but depend on browser support and user permission. Interactive maps can be provided with open-source libraries such as Leaflet [15]. The user-facing stack of the platform is built with React [21] and Vite [22], with persistence through Sequelize [23] and MySQL [24].

Capacitive and dielectric sensing of cooking oil has been investigated as a rapid alternative to laboratory analysis. Total polar compounds are a widely used indicator of frying-oil degradation, and quality-control practice for deep-frying oils has long relied on such indicators [25]. Liu et al. [8] reported a portable sensor based on dielectric constant measurement for frying-oil evaluation, and Fendri et al. [9] presented a measurement system for lossy capacitive

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sensors applied to edible-oil quality assessment. Cataldo et al. [26] examined dielectric spectroscopy for the quality and anti-adulteration control of vegetable oils. The fundamentals of capacitive sensor design are covered by Baxter [27]. These studies relate dielectric response to oil condition, but their calibrations do not transfer automatically to a different probe, and temperature and probe geometry strongly affect measurements.

IoT architectures connect sensing devices to networked services. Atzori et al. [28] and Gubbi et al. [29] survey the elements and challenges of IoT systems, including identification, communication and security. For the proposed node, the Texas Instruments FDC1004 [30] provides capacitance-to-digital conversion over an I²C interface, the DS18B20 [31] provides digital temperature measurement over a 1-Wire interface, and the ESP32 [32] provides Wi-Fi connectivity. For the planned comparison of sensor estimates with reference measurements, method-comparison statistics [33] provide an established way to describe agreement and bias.

A. RESEARCH GAP AND MOTIVATION

Prior work provides individual elements: official complaint channels, educational adulteration guidance, secure web-application practices and oil-sensing studies. However, a student-built, independent platform that combines a low-friction multilingual complaint workflow, permissioned case review, privacy-aware advisory analytics and a clearly separated experimental oil-sensing module has not been presented in a single design. The motivation of this work is to integrate these elements while stating plainly what is implemented and what is only proposed. This is a system-level design objective; the effectiveness of the reporting workflow with real users and the accuracy of any oil-sensing estimate must be established through testing and are not assumed here.

PROBLEM STATEMENT

Citizens who wish to report unsafe food may not know the vendor name, registration number or exact address, and long web forms can discourage them from submitting. Once a complaint is received, it needs controlled access, traceable review and prioritization, but a user report is not an automatically confirmed violation. In addition, repeated frying degrades cooking oil, and reliable assessment of oil quality requires appropriate reference measures, so that appearance alone or an uncalibrated electrical reading cannot be treated as a safety verdict. Therefore, a platform is required that makes reporting accessible, protects privacy across user roles, supports human review with advisory intelligence, and explores an accountable path from citizen reports to measured evidence.

OBJECTIVES:

I. Combine accessible complaint processing with an experimental iot pathway for cooking-oil deterioration monitoring in one research design.

II. Streamline citizen complaint registration and tracking through a guided, multilingual form with voice, gps, map-pin and manual-location alternatives.

III. Protect privacy across customer, admin and authority roles using authentication, role-based access control, complaint-ownership checks and evidence authorization.

IV. Provide educational adulteration screening and advisory intelligence (risk, duplicate matching and hotspot analysis) that assist, but do not replace, human reviewers.

V. Determine whether a controlled capacitive probe can detect reproducible differences among oil samples, as a testable engineering question.

VI. Define how strongly measured changes relate to reference tpc through an independent calibration and validation protocol.

VII. Store and display sensor results in the existing dashboard without presenting unvalidated safety verdicts.

CASE REVIEW WORKFLOW AND EVIDENCE HANDLING

the platform organizes complaint handling into connected stages so that each report can be tracked, reviewed and acted upon within defined permissions.

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- submission of a complaint with food category, narrative, optional seller or landmark, optional image and optional location.
- validation of input and issue of a unique public complaint identifier before the complaint is stored.
- admin triage and verification, including risk overview, duplicate review and private evidence review within permissions.
- authority action on permitted or assigned cases, with investigation actions, case history and remarks.
- customer tracking of status through a view limited to complaints owned by that customer.

SIGNIFICANCE OF THE STUDY

This research addresses the need for an accessible and accountable route from citizen food-safety reports to reviewed cases. By allowing optional unlisted-seller details, language and voice alternatives and several location methods, the platform lowers practical barriers to reporting. By separating Customer, Admin and Authority workspaces and enforcing checks on the server, it aims to protect privacy and support traceable review. The proposed oil-sensing module adds a clearly labelled experimental direction for measured evidence without claiming validated results.

III. SYSTEM ARCHITECTURE AND MODULE DESCRIPTION

The platform architecture is divided into a presentation layer, an application-processing layer and a persistence layer, with a proposed IoT branch (Fig. 1). The React and Vite client provides multilingual interfaces, role-aware routes and evidence capture for Customer, Admin and Authority users. The Node.js and Express services expose REST APIs for authentication and role-based access control, complaint handling, screening guidance and intelligence services. MySQL, accessed through Sequelize, stores users, sellers, complaints, evidence references, case actions and audit information. Exact details should be confirmed against the final code revision.

The customer module implements the FoodSafe Easy form: a guided four-step process with progressive disclosure, clear prompts and a review stage before submission. Users may select a food category, describe the concern, name a seller or give a landmark when the seller is unlisted, attach an optional image, and provide location by browser GPS, a draggable map pin or a manual address. English, Hindi and Marathi interface dictionaries are available, and speech-to-text input can be edited before submission. Accessibility and completion-rate gains from these features have not been independently measured.

The admin and authority modules provide separate, permissioned workflows. Administrators perform complaint triage and verification, manage sellers and reports, and review risk, duplicates and hotspots. Authority users see permitted or assigned cases, record investigation actions and case history, and view relevant evidence and remarks, with read-only intelligence where authorized. Backend role and ownership checks are mandatory; hiding routes on the client alone is not authorization, as emphasized by API security guidance [6].

The advisory intelligence module supports reviewers without issuing accusations. Complaint risk is computed from a rule-based category baseline and keyword weights and is used to order cases for human review; it is not a calibrated clinical or regulatory probability. Possible duplicates are identified by comparing seller or product, description, location and time factors, with textual similarity modelled using Jaccard overlap [19]. The hotspot grid groups complaints into approximate 1 km cells and applies a privacy-aware output threshold (reported as five or more complaints), redaction and role checks, in the spirit of k-anonymity [18].

The data and security layer uses authenticated requests [5], role-based access control [4], complaint-ownership checks, evidence authorization and server-side privacy rules. The conceptual data model comprises Users (role and identity), Complaints (public complaint ID and content), Sellers (optional association), Evidence (private metadata or files), Case Actions (status and history) and Geo Analytics (coarse aggregation). This is a conceptual model for an entity-relationship diagram and not an exhaustive verified schema.

The proposed IoT module is separate from the implemented platform. A sensor node would send capacitance, temperature and a sample identifier to a device-authenticated REST endpoint, where raw values and calibration

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metadata would be stored for display on a separate experimental page. Proposed tables include iot_devices, oil_samples, oil_measurements, oil_calibrations and reference_tpc_results, and the proposed API includes a POST endpoint for measurements, history retrieval and authenticated Admin calibration and audit endpoints. Administrator tokens and database credentials must never be embedded in device firmware, and synthetic test data must be distinguished from real hardware data.

The platform is designed to make reporting accessible, review accountable and analytics privacy-aware, while keeping a strict boundary between implemented software and the proposed sensing research. Its value lies in reducing practical barriers to reporting, supporting traceable case handling and providing a documented path for future experiments. The approach is intended to be useful in academic and community settings; its real-world effectiveness will require usability, deployment and validation studies.

IV. PROPOSED METHODOLOGY

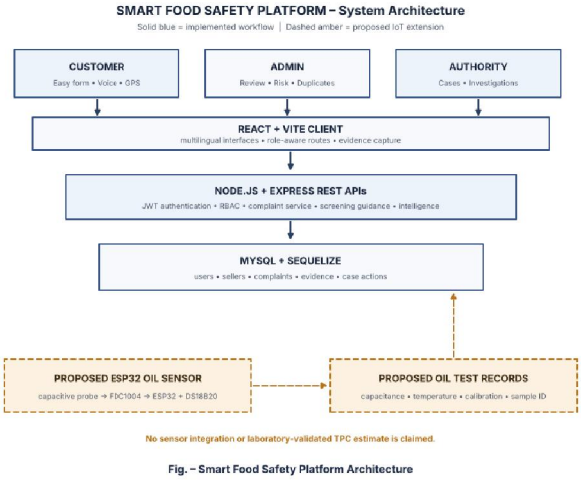


Fig. 1 System Architecture

- **Proposed Methodology for the Platform**

  This research follows a design-science, system-design and verification approach [34], [35] to develop the platform as an integrated artefact. The implemented component is built and tested as a software system: requirements are derived from the reporting, response and measurement barriers; the React/Vite client, Express services and MySQL/Sequelize data layer are developed; and role workflows, privacy rules and advisory analytics are verified through unit, integration and browser tests [36]. A complaint passes through six stages, from report to authorized review (workflow described in the implementation section below).

  The proposed component follows an experimental-protocol approach. A fixed-geometry capacitive probe connected to an FDC1004 and an ESP32 would measure controlled, cooled oil samples (Fig. 2). Electrical data would be recorded first, and chemical quality would be inferred only after independent reference measurement and validation. The two components share the web backend, but their evidence status is kept separate throughout this paper.

IMPLEMENTATION METHOD AND STUDY DESIGN

- **SOFTWARE VERIFICATION AND EVALUATION:**
- Automated Verification: Unit, integration and Chrome Playwright runs of the web platform are reported by the developers, including role-specific routes, schema hardening and complaint-ID hardening. Staging and the latest teammate interface still require verification.

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V. PROPOSED EXPERIMENTAL PROCEDURE

The proposed oil-sensing study is organized in three phases. Phase A addresses electronics: known reference capacitors are measured to check baseline stability, measurement noise, sensor reconnects and temperature behaviour. Phase B addresses samples: the study begins with one controlled oil type and documents fresh and used samples, independent batches and sample conditions. Phase C obtains reference TPC values from a validated, independent method, with separate oil batches blinded or held out for evaluation. Sample counts, degradation stages and heating protocols must be finalized with a competent laboratory.

The custom stainless-steel probe is the physical test fixture, and its design is critical. Fixed electrode separation and overlap, rigid insulating spacers, consistent immersion depth and short, shielded leads when appropriate are required. Samples are measured cooled at first in clean, dry containers, with temperature and timing controlled and oil origin and batch documented. Fringe and parasitic capacitance, water and particles, oil type, probe contamination and FDC1004 offset and drift are recognized sources of noise [30], [27]. The study starts with known capacitors and fresh oil before any degradation correlation is attempted.

The parallel-plate approximation $C \approx \varepsilon_0 \varepsilon r\, A / d$ [27] indicates that capacitance depends on the dielectric constant of the oil and on probe geometry. The derived quantity $\Delta C = C_{sample} - C_{fresh}$ is compared at matched temperature and probe geometry. The direct outputs are capacitance (pF) and temperature (°C); the derived output is change from baseline (pF or %); TPC (%) and a safety verdict are not direct outputs. A 6% capacitance difference does not mean that the oil is 6% degraded or 6% adulterated.

A candidate calibration model has the form $\hat{TPC} = a + b \cdot \Delta C + c \cdot (T - T_{ref})$, where the coefficients a, b and c are to be estimated from actual reference data and oil-specific models may be necessary. Validation would hold out entire oil batches rather than only repeat readings, and report mean absolute error and root-mean-square error in TPC percentage points, bias, uncertainty and failures near the 25% reference limit [7]. Agreement with reference values would be described using method-comparison statistics [33]. The 25% criterion applies to independently established TPC and must never be applied to uncalibrated ΔC or relative electrical change. No performance should be claimed until these measurements have actually been collected.

- **Sample Handling:** Use clean, dry containers, measure cooled samples first, control temperature and timing, and document the oil origin and batch for every measurement.
- **Reference Measurement**: Obtain independent TPC values from a validated method and use them only for calibration and for evaluation on held-out batches.

FUNCTIONAL ANALYSIS

Module Testing: Individual modules, including complaint submission, validation, authentication and role checks, evidence handling, screening guidance, risk and duplicate analytics, and the hotspot grid, are examined.

Workflow Testing: The complete workflow is reviewed from customer submission through admin review and authority action to customer tracking, with ownership and privacy checks at each stage.

SYSTEM IMPLEMENTATION AND PROCESSING

Report Concern: The customer submits a concern through the FoodSafe Easy form or the standard form, with food category and narrative.

Validate Input: The server validates the input; the seller may be unlisted, and the image and location are optional.

Issue Unique ID: A unique public complaint identifier is issued and the complaint is saved in MySQL.

Admin Review: The administrator triages and verifies the complaint, with advisory risk, duplicate and hotspot information.

Authority Action: The authority performs permitted investigation actions and records them in the case history.

Track Status: The customer tracks status through a view limited to his or her own complaint.

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VI. DISCUSSION, LIMITATIONS AND THREATS TO VALIDITY

The implementation evidence is of a specific kind. Developers report that 289 of 289 automated checks passed in Phase 6.1, together with unit, integration and Chrome Playwright runs and reported schema and complaint-ID hardening. These are developer-reported results that were not newly rerun for this paper, they concern software verification only, and they say nothing about user outcomes or about the oil sensor. Staging and the latest teammate user interface still require verification.

Several limitations apply to the web platform. Public hosted reliability, real-user task completion and accessibility outcomes have not been measured. Speech recognition depends on browser support, and location depends on user permission, which can be denied. Screenshots used during development come from an earlier application snapshot and do not prove deployment or complete verification of the current build. An Authority Investigations blank-screen issue was reported in a teammate environment and remains an open item to verify. Details of the implementation should be confirmed against the final repository revision.

The advisory analytics are heuristic. Risk scores are rule-based and are not calibrated probabilities, duplicate matching is a similarity aid, and the hotspot grid is a coarse, privacy-aware aggregation. No trained deep-learning inference or statistically validated risk prediction is claimed, and the educational screening feature must not be read as laboratory diagnosis. The platform is independent and must not be represented as an official FSSAI regulatory service.

For the proposed IoT module, threats to validity include probe geometry and fabrication variability, parasitic capacitance, temperature dependence, oil type and contamination, small or non-independent sample sets and the reliability of reference TPC measurements. Capacitance is not TPC, and cooking-oil deterioration monitoring is not detection of a specific added adulterant. To improve validity, future experiments should use independent batches, documented procedures, held-out evaluation and honest reporting of failures.

Scope Statement: Software verification is distinct from user outcomes and from oil-sensor validation; none of the sensor-related elements described in this paper has yet been experimentally validated.

KEY FRAMEWORKS AND TECHNOLOGIES USED: REACT, VITE, NODE.JS, EXPRESS, SEQUELIZE, MYSQL, LEAFLET, WEB SPEECH API AND PLAYWRIGHT; PROPOSED ESP32, FDC1004 AND DS18B20.

- EVALUATION METRICS
- SOFTWARE VERIFICATION CRITERIA:

Role Enforcement: Whether backend role checks restrict Admin and Authority functions.

Complaint Ownership: Whether customers can access only complaints they own.

Workflow Completion: Whether a complaint can progress from submission to authority action and customer tracking.

Evidence Access Control: Whether private evidence is available only to authorized roles.

Privacy Thresholding: Whether hotspot output follows the reported minimum-count threshold and redaction rules.

Automated Check Results: The reported pass count (289 of 289 in Phase 6.1) as a developer-reported software indicator.

- **PROPOSED SENSOR VALIDATION CRITERIA:**

  Repeatability of capacitance readings for known capacitors and controlled oil samples.

  Temperature behaviour and stability of baseline readings.

  Agreement between estimated and independently measured TPC, reported as MAE, RMSE and bias on held-out batches.

  Performance of the model near the 25% TPC reference limit and in out-of-batch prediction tests.

- **ETHICAL AND RESPONSIBLE USE CONSIDERATIONS**

  Privacy Protection: Keep complaint identity, evidence and location private and enforce access on the server.

  Advisory Use Only: Present risk scores and screening output as decision support and not as confirmed violations or laboratory results.

Honest Reporting: Label proposed components as proposed and record pass or fail only from real logs and measurements.

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EXPECTED OUTCOMES

ACCESSIBLE COMPLAINT REPORTING AND PRIVATE TRACKING.
ROLE-BASED, TRACEABLE ADMIN AND AUTHORITY CASE WORKFLOWS.
PRIVACY-AWARE ADVISORY RISK, DUPLICATE AND HOTSPOT ANALYSIS.
A REPRODUCIBLE PROTOCOL FOR VALIDATING A CAPACITIVE COOKING-OIL SENSOR.

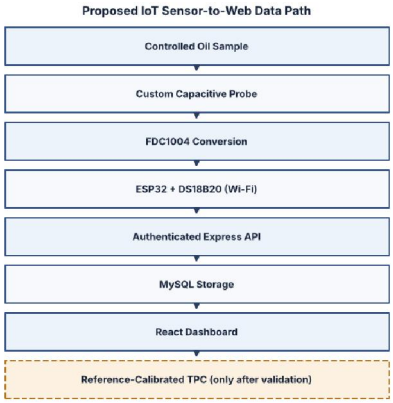


Fig. 2 Proposed IoT Sensor-to-Web Data Path

Controlled Oil Sample
→ Cooled, clean sample with documented origin and batch
Custom Capacitive Probe
→ Fixed electrode geometry with oil as the dielectric
FDC1004 Conversion
→ Capacitance measured and sent over the I²C interface
ESP32 + DS18B20
→ Capacitance, temperature and sample ID timestamped for Wi-Fi transmission
Authenticated Express API
→ Device authentication and validation of each upload
MySQL Storage
→ Raw values and calibration metadata kept separate from reference results
React Dashboard
→ Trends and warnings shown without safety verdicts
Reference-Calibrated TPC
→ Reported only if validated on held-out, reference-measured samples

THEORETICAL FRAMEWORK

The theoretical framework of the platform is based on design science, access control and privacy, heuristic decision support, and dielectric sensing with calibration. These concepts guide a design that transforms citizen reports into traceable cases and defines how a sensor prototype should be validated before any measured claim is made.

· **Design Science:**

Design-science research builds and evaluates an artefact that addresses an identified problem [34], [35]. Here the artefact is a reporting-and-review platform and a proposed sensing module, and the evaluation distinguishes what has been verified from what remains to be tested.

· **Access Control and Privacy:**

Role-based access control [4], token-based authentication [5] and the API security guidance [6] ground the Customer, Admin and Authority separation, while k-anonymity [18] grounds the suppression of small groups in hotspot output.

· **Heuristic Decision Support:**

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Rule-based scores and set-overlap similarity [19] organize work for human reviewers. They are transparent and inexpensive, but they are not trained or calibrated predictors and must be interpreted as advisory.

· **Capacitive Sensing and Calibration:**

A capacitive probe responds to the dielectric properties of the oil and to probe geometry [27]. Because TPC is a chemical indicator [25], [7], an electrical reading becomes a TPC estimate only through calibration against independent reference data, and agreement should be evaluated with appropriate statistics [33].

· **Synthesis of Frameworks:**

Together, design-science evaluation, access control and privacy, heuristic decision support, and calibrated sensing [8], [9] provide the conceptual basis for the platform and for the status labels (implemented or proposed) used throughout this paper.

CONCLUSION: SMART FOOD SAFETY PLATFORM

VII. IMPLEMENTATION CONSIDERATIONS AND FUTURE ENHANCEMENTS

Before submission or deployment, the final code revision should be verified, including the reported Authority Investigations blank-screen issue, and current screenshots and test logs should be collected. Details such as status names and technology versions in this paper should be confirmed against the repository. Staging and the latest teammate user interface still require verification.

Security hardening remains essential for an application that accepts complaints, location and evidence. Backend role and ownership checks, evidence authorization and server-side privacy rules should be kept consistent with API security guidance [6], and credentials and secrets must be stored outside the client and outside device firmware.

For the IoT module, new database models, device credentials and a separate experimental user-interface route are required. Device uploads should be authenticated and validated, calibration and audit endpoints should be restricted to Admin users, and synthetic test data should be marked so that it cannot be mistaken for measurements from real hardware.

Hardware details such as exact breakout pinout, decoupling, grounding, probe leads and shielding must be verified from manufacturer data [30], [31], [32] before fabrication, and the illustrated connections in this paper should not be treated as a fabrication-ready schematic.

This paper presented the Smart Food Safety Complaint and Food Adulteration Platform, an implemented full-stack web application, together with a proposed ESP32-based IoT extension for experimental cooking-oil monitoring. The work responds to a reporting barrier, a response barrier and a measurement barrier in food-safety practice.

The implemented platform provides a guided multilingual complaint form with voice and location alternatives, private complaint tracking, separate Admin and Authority workflows, educational adulteration guidance, and privacy-aware advisory analytics built on React, Express and MySQL. Developers report that 289 of 289 automated checks passed in Phase 6.1; this is a software-verification indicator that was not independently rerun here.

The proposed IoT module defines how an ESP32, an FDC1004 and a custom capacitive probe could record capacitance and temperature of controlled oil samples, and how TPC estimation could be attempted only after independent reference calibration. It is a design and protocol, not a validated instrument, and no sensor accuracy or TPC result is claimed.

The platform is an independent academic implementation and is not an official FSSAI service; it does not provide certified detection of adulterants and does not replace accredited laboratory testing. The paper's contributions are the integrated reporting-and-review design, the privacy-aware advisory layer and a reproducible validation plan, and further testing is needed before outcomes can be claimed.

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FUTURE SCOPE: ADVANCEMENTS IN THE SMART FOOD SAFETY PLATFORM

A. Final-Release Verification

Future work should verify the final code revision, resolve the reported Authority Investigations issue, rerun the automated checks and collect accurate screenshots and logs for publication.

B. Usability and Accessibility Studies

Studies with intended users should measure task completion, completion time and accessibility of the multilingual, voice and location features, since these gains have not yet been independently measured.

C. Device Fabrication and Electrical Calibration

The electrode probe should be fabricated and wired to the FDC1004, and known capacitors and cooled oil baselines should be measured to characterize noise, drift and temperature behaviour.

D. Independent Reference TPC Campaign

Independent oil batches should be recorded together with temperature and independently measured reference TPC from a validated method, with sample numbers and heating protocols finalized with a competent laboratory.

E. Calibration and Model Validation

Candidate calibration models, including oil-specific models, should be evaluated on held-out batches and reported with error, bias, uncertainty and failures near the 25% reference limit.

F. End-to-End Web Integration

The proposed tables, device-authenticated API and separate experimental dashboard route should be implemented and tested end to end, with PASS or FAIL recorded from real logs and measurements.

G. Broader Deployment and Evaluation

The platform could be evaluated in pilot deployments for hosted reliability, user outcomes and reviewer workload, and extended with additional languages and carefully validated analytics.

Further development and independent testing could help establish the usefulness of the platform in practical food-safety workflows. Evaluation findings could guide improvements to the complaint form, the reviewer workspaces and the clarity of advisory information.

Future research could compare design choices for the reporting workflow, such as form length, progressive disclosure and voice input, to determine how they affect completion and report quality, and whether privacy-aware aggregation remains useful for reviewers.

Additional work could examine whether a calibrated capacitive probe can support reliable oil-quality screening across oil types, and how a validated estimate should be communicated so that it is not mistaken for a regulatory verdict.

Over time, the platform could include verified image-analysis support, expanded educational content and validated sensor modules, provided each addition is separately tested and its status is reported honestly.

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