

Reference-Anchored Multi-Dilution Electronic Tongue for Ayurvedic Dravya Identification

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Abstract — Ayurvedic Dravya identification is an important process in Ayurveda, as the correct identification of medicinal substances supports their appropriate use and quality assessment. However, identifying Ayurvedic Dravya based on sensory characteristics such as Rasa (taste) can be challenging because different substances may exhibit similar taste profiles, while their responses can vary with sample concentration, solvent composition and preparation conditions. Traditional sensory evaluation also depends on human perception and may introduce subjectivity. An electronic tongue (E-tongue), which uses an array of chemical sensors to generate measurable response patterns, offers a potential approach for objective and repeatable taste-related analysis. This paper proposes a Reference-Anchored Multi-Dilution Electronic Tongue framework for Ayurvedic Dravya identification. The proposed system evaluates each sample at multiple predefined dilution levels to obtain a more representative sensor-response fingerprint. The collected signals are preprocessed, normalised and compared with reference fingerprints stored in a database using a deterministic distance-based matching method. Unlike approaches that depend on artificial intelligence or machine-learning classification, the proposed framework focuses on reference-based comparison, controlled sample preparation, sensor calibration and predefined acceptance criteria. The system is designed to provide the closest reference match when the similarity criteria are satisfied and a “No Reliable Match” result when the evidence is insufficient. The paper also discusses key challenges, including sensor drift, variation in sample composition, solvent effects, dilution consistency and the need for laboratory reference validation. The proposed framework may support the development of a transparent and reproducible electronic-tongue system for Ayurvedic Dravya screening. Experimental validation with authenticated samples is required to establish its identification performance, repeatability and practical suitability.

Keywords— Ayurvedic Dravya, Electronic Tongue, Rasa Identification, Multi-Dilution Analysis, Chemical Sensor Array, Reference Fingerprinting, Deterministic Matching, Sensor Calibration.

I. INTRODUCTION

Ayurvedic Dravya are medicinal substances used in Ayurveda, and their correct identification is important for maintaining the quality and consistency of Ayurvedic preparations. Traditional identification methods often involve evaluating sensory properties such as Rasa (taste), along with other physical and pharmacognostic characteristics. However, sensory evaluation may vary between individuals, and substances with similar taste profiles can be difficult to distinguish. In addition, sample concentration, solvent composition and preparation conditions can influence the perceived taste and measured chemical response [1], [2].

An electronic tongue (E-tongue) is a chemical sensing system that uses an array of sensors to generate measurable response patterns from liquid samples. These patterns can be used to compare the taste-related characteristics of different substances. Previous research has investigated the application of electronic tongues to medicinal plants and Ayurvedic Rasa assessment, while also highlighting challenges associated with

solvent selection, sample concentration and sensor response [1]–[3]. These findings indicate the importance of standardised sample preparation and reliable reference measurements when developing an electronic-tongue-based identification system.

For Ayurvedic Dravya identification, three important elements can be combined: chemical sensor arrays for acquiring sample-response signals, multi-dilution analysis for observing response patterns at different predefined concentrations, and a reference fingerprint database for comparing unknown samples with authenticated samples. This paper proposes a Reference-Anchored Multi-Dilution Electronic Tongue framework that uses deterministic distance-based matching rather than an AI or machine-learning classifier. The proposed system is designed to compare processed sensor responses with stored reference fingerprints and provide a reliable match only when predefined acceptance criteria are satisfied. If the available evidence is insufficient, the system returns a “No Reliable Match” result. This approach aims to support objective, repeatable and transparent screening of Ayurvedic Dravya, while recognising

that experimental validation is necessary to establish its identification performance and practical applicability.

II. REVIEW METHODOLOGY

A focused review of electronic-tongue systems, chemical sensors, Ayurvedic Dravya, herbal samples, dilution techniques, and reference-based measurement methods was considered to develop the proposed framework. Relevant studies were examined for their sensing principles, sample preparation procedures, calibration methods, repeatability, and quantitative evaluation approaches.

III. SENSING TECHNOLOGIES FOR AYURVEDIC DRAVYA

1. Laboratory and Electrochemical Sensing

Laboratory-based analytical techniques provide important information about the physical and chemical properties of Ayurvedic Dravya. Electrochemical sensing methods, including potentiometric and voltammetric measurements, can record changes in electrical signals associated with the chemical characteristics of liquid samples.

Potentiometric sensors measure voltage differences, while voltammetric techniques examine current responses under controlled electrical conditions. These methods can support the comparative evaluation of selected samples when appropriate calibration procedures and reference measurements are used. However, sensor responses may be affected by sample composition, concentration, temperature, electrode condition, and preparation procedures. Therefore, controlled sample handling and suitable reference methods are important for obtaining reliable results.

2. Multi-Sensor and Reference-Based Measurements

An electronic tongue combines multiple chemical sensors to generate a response pattern from a liquid sample. Different sensors may respond differently to the same sample, producing a multidimensional fingerprint that can be recorded and compared.

For Ayurvedic Dravya, this approach may support the systematic comparison of selected liquid preparations under standardised conditions. However, a single measurement may not sufficiently distinguish sample variation from sensor drift or concentration effects.

IV. MACHINE LEARNING AND DEEP LEARNING METHODS

1. Rule-Based Comparison Versus Complex Analytical Methods

Rule-based comparison provides a transparent approach for evaluating sensor responses without depending on machine-learning or deep-learning models. In the proposed Reference-Anchored MultiDilution Fingerprinting (RAMDF) framework, predefined rules are used to compare the recorded response patterns of Ayurvedic Dravya with suitable reference measurements. The comparison considers response consistency, variation across dilution levels, and repeatability under controlled conditions. Unlike complex predictive models, this approach allows the decision process to be inspected and understood directly.

2. Reference-Anchored Multi-Dilution Comparison

RAMDF combines reference-solution verification with measurements obtained at multiple dilution levels. Initially, the sensor system is checked using a reference solution under defined measurement conditions. The selected Ayurvedic sample is then prepared according to a standardised procedure and measured at predefined dilution levels. The resulting sensor responses are recorded and compared with the corresponding reference patterns. Repeated measurements help identify inconsistent responses, while reference checks provide information about possible sensor drift.

3. Comparative Evaluation of Analytical Approaches

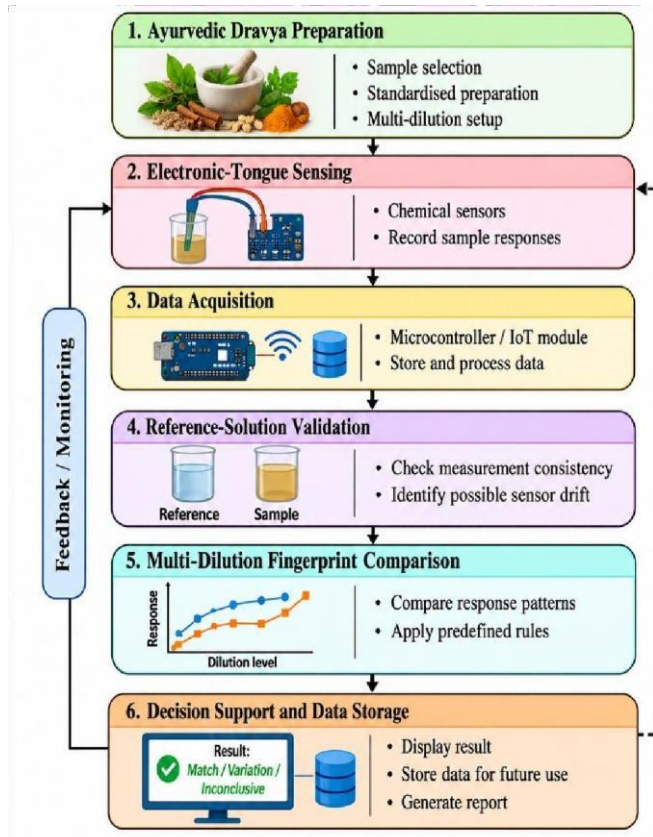
Laboratory analysis provides established methods for evaluating sample properties, while electronic-tongue systems record response patterns from multiple chemical sensors. Single-level sensing is simple but provides limited information about changes in sensor responses with concentration.

V. IOT INTEGRATION AND EDGE DEPLOYMENT

The proposed Reference-Anchored Multi-Dilution Fingerprinting (RAMDF) framework can be extended with Internet of Things (IoT) technology to support the recording and monitoring of electronic-tongue measurements. Sensor readings obtained at different dilution levels can be transferred to a microcontroller for recording and preliminary processing. An edge device can store measurement data, compare sensor responses with predefined reference values, and display the result locally. If network connectivity is available, the recorded

data can also be transmitted to a cloud platform for storage, report generation, and remote monitoring..

VII. PROPOSED CONCEPTUAL ARCHITECTURE



VIII. RESEARCH GAPS AND FUTURE DIRECTIONS

Research Gaps. The evaluation of Ayurvedic Dravya using electronic-tongue systems faces several challenges. (i) Limited studies specifically validate electronic-tongue measurements across different Ayurvedic samples. (ii) Variations in sample preparation, dilution, and environmental conditions may affect sensor responses. (iii) Sensor drift and calibration errors can reduce measurement consistency. (iv) Single-concentration measurements may not adequately capture response changes across different dilution levels. (v) The use of reference solutions and repeatability checks requires further investigation. (vi) Standardised comparison procedures and

validated acceptance limits remain important requirements for reliable evaluation.

Future Directions. Future work should investigate the RAMDF framework using multiple Ayurvedic Dravya samples under controlled and repeatable conditions. Experiments should include standardised sample preparation, predefined dilution levels, reference-solution Bombale Sukanya Vikas Dept. of Computer Engineering Jaihind College of Engineering Pune, India bombalesukanya@gmail.com Dr. Anand Khatri HOD Of Dept. of Computer Engineering Jaihind College of Engineering Pune, India khatrianand@gmail.com Prof. Bangar Abhishek Popat Dept. of Computer Engineering Jaihind College of Engineering Pune, India abhishekpbangar@gmail.com Prof. S.B.Bhosale Dept. of Computer Engineering Jaihind College of Engineering Pune, India ssachinbhosale@gmail.com measurements, and

repeated sensor readings. Comparisons with suitable laboratory reference methods are required to evaluate the consistency and reliability of the recorded fingerprints. Further research should examine sensor stability, temperature effects, measurement uncertainty, and the suitability of rule-based comparison criteria. Data recording and optional IoT integration may support longterm monitoring and result management. These investigations can help establish the practical feasibility and limitations of RAMDF for Ayurvedic Dravya evaluation.

IX. CONCLUSION

The proposed Reference-Anchored Multi-Dilution Fingerprinting (RAMDF) framework presents a structured approach for evaluating Ayurvedic Dravya using electronic-tongue technology. By combining standardised sample preparation, multi-dilution measurements, reference-solution validation, and rule-based comparison, the framework aims to improve measurement consistency and transparency. Unlike AI-based approaches, RAMDF uses predefined rules to identify matching response patterns, variations, or inconclusive results.

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