

PROJECT TITLE: PORTABLE SPECTROMETER TO ASSESS THE CONCENTRATION OF ACTIVE CHEMICAL INGREDIENTS IN SPICES

1. TECHNOLOGY BACKGROUND: NIR SPECTROSCOPY & MACHINE LEARNING

For applications such as pharmaceutical, food, and agriculture testing and screening, **NIR (near infrared) spectroscopy** is a proven technology that delivers accurate results. A spectroscopic method that uses the near-infrared region of the electromagnetic spectrum, NIR is based on overtones and combinations of bond vibrations in molecules. In NIR spectroscopy, the unknown substance is illuminated with a broad-spectrum (many wavelengths or frequencies) of near infrared light, which can be absorbed, transmitted, reflected or scattered by the sample of interest. The illumination is typically in the wavelength range of 0.8 to 2.5 microns (800 to 2500nm). The light intensity as a function of wavelength is measured before and after interacting with the sample, and the diffuse reflectance, a combination of absorbance and scattering, caused by the sample is calculated.

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

2. BUSINESS BACKGROUND: ITC AGRI BUSINESS

ITC's Agri Business is the country's second largest exporter of **agri-products**. It currently focuses on exports and domestic trading of Food Grains, Spices, Marine Products, Processed Fruits and Coffee.

ITC Spices Business, is one of India's leading producers and exporters of Backward Integrated Food Safe Spices. Located in Guntur, the "chilli capital of the world", ITC Spices currently handles more than 25,000 MT of chilli, turmeric, coriander, ginger, seed spices and blended spices. Further, the ITC Spices Business strives to deliver the highest quality to its customers and addresses their food safety concerns by nurturing process driven value chains.

Food Safety, Quality and sustainability form the cardinal principles of ITC's spices business. With such huge scale of operations and stringency in principles, procurement plays an important node in the entire Spices Value Chain.

3. PROBLEM STATEMENT:

The procurement of raw material takes place in different manner for different kind of spices. While procuring the raw material is to be tested for various chemical parameters because of the huge variability in the incoming agri commodity. In case of turmeric, different tests are conducted to know the concentration of curcumin content, moisture, starch and foreign materials. Further, testing is also done at various nodes throughout the value chain like storage, processing and finished goods. Each of these tests are performed on conventional laboratory equipment subject to longer lead times.

Curcumin content is found by extracting the curcumin in the form of a solution which takes 2 hours and further the concentration will be determined using a UV – Spectrophotometer equipment which requires another 30 minutes and additional lead time based on equipment availability and resource availability.



HPLC Equipment



The testing process includes certain and inherent limitations which include:

- i. **Inaccessible laboratories:** The laboratories are located far from the buying and processing units increasing the lead times.
- ii. **Huge Testing Costs:** The laboratory tests are capital intensive and further requires high cost resources and inputs.
- iii. **Time Consuming & Delayed decision making:** Due to larger lead times for testing buying decisions get delayed.

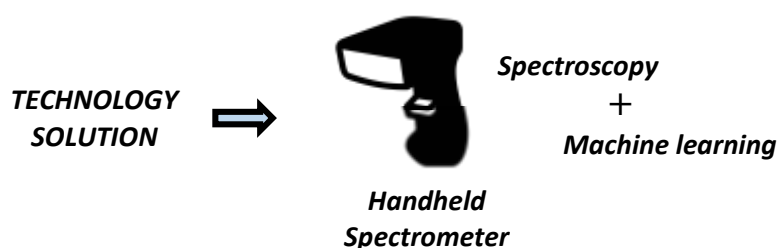
To overcome these shortcomings, ITC – ABD envisages to develop a portable solution to measure the concentration of active ingredients in different spices.

The technology is tested for Curcumin content in Turmeric with good accuracies.

4. SOLUTION FRAMEWORK

The portable device works on the principle of NIR spectroscopy integrated with Machine Learning algorithms. This device will be trained with different samples spanning across the complete range of curcumin content. The spectra of the samples trained will be captured in the 900 nm – 2500 nm wavelength range.

System training will be done by mapping the spectra with the value of curcumin content in the sample. A set of pre-processing statistical techniques along with Machine Learning algorithms are designed in place once the spectra is captured. Depending upon the robust training of the device with multiple samples, the accuracy of the predicted values will vary.



5. INNOVATION COMPONENT

The unique element of the solution is the development of technology for identification and measurement of chemical parameters using advanced machine learning algorithms. Machine learning models are trained on the spectral signatures of the chemicals.

The solution in itself is a first of its kind where it is being deployed for testing chemical attributes in the incoming agri commodities with high variability.

The device is a handheld portable spectrometer which enables testing at any kind of location not just restricting it to the conventional laboratories. It is advantageous over the conventional devices in terms of cost and accessibility. Further, the device design also ensures effortless handling.

6. BUSINESS BENEFIT

For any industry in the space of procurement, trading and processing of turmeric, this device aids in establishing a “Test & Buy” strategy towards targeted buying.

This device also helps in reducing lead times, remove manual interventions. It will further improve the operational efficiency as the testing can be performed on site (outdoor locations).

- a. Reduction in lead times for testing from 4 hours to instantaneous testing.
- b. 60% reduction in the testing costs when compared to the conventional methods of testing.
- c. Elimination of costs pertaining to samples, transport of samples from various locations to laboratory and skilled manpower through this rapid method of testing.
- d. Highly de-skilled to generate data on site.
- e. Enables Test and buy model to enable business capture value and ensures the selection of right material and thus optimizes the blend cost.
- f. Reduces information bias at the procurement step.

7. CURRENT STATUS

Multiple models have been developed and tried with various samples to measure the percentage of Curcumin in turmeric. One specific model with an R^2 of 98 % has been chosen for initial trails. The results have fared comparable to the acceptable method of testing (ASTA). A working prototype is being deployed in specific procurement locations for Turmeric.

MODEL RESULT	
Chemical Parameter Tested	Curcumin
R^2	0.98
Average % error	3 %
SD in Measurement	0.43