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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

THE POTENTIAL OF FIBER OPTIC DISPLACEMENT SENSOR (FODS) IN DETECTION POLYPHENOL LEVEL IN VARIOUS TYPE OF GREEN TEA

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Abstract: Green tea is renowned for its rich polyphenol content, which acts as a powerful antioxidant and offers numerous health benefits. Nevertheless, overconsumption of green tea polyphenol could lead to liver damage, harming human health. Traditional methods of detecting polyphenol in green tea involve chemical reagents, expensive instrumentation, and skilled personnel. Therefore, this study aims to address these limitations by implementing a Fiber Optic Displacement System (FODS) for evaluating polyphenol levels in green tea extracts. The methodology involves extracting polyphenol from various green tea samples using methanol before analyzing them using the FODS, which consists of fiber probes to measure light intensity reflected from the samples, detected by a photodiode. The result shows that as polyphenol concentration increases, the peak voltage output will also increase, indicating higher polyphenol levels. The performance of this linear calibration of various green teas at concentration of 2124 ppm is 0.052 V/ppm for sensitivity, linearity of 96.57%, LOD of 4.335 V and 13.137 V for LOQ. FODS offers a cost-efficient and quick setup solution for various settings, including the food industry for quality control, research laboratories, and health-conscious consumers. This development could revolutionize polyphenol content assessment, making it accessible and practical for a broader range of users.

***Keywords*:** *Green tea, polyphenol, FODS*

INTRODUCTION

According to current trends, people typically use supplements or organic products to keep their bodies healthy and energetic. Tea is consumed mostly by humans around the world, after water, which has a generous amount of beneficial functional components that can be found. Undoubtedly, green tea derived from Camellia sinensis stands out as a popular great source of health promoting compounds (Musial et al., 2020). Green tea is the type of tea that has the highest composition of polyphenol where the polyphenol themselves makes up most of the composition. The primary components of green tea, making about 24–36% of its dry weight, are polyphenol compounds. Towards the end of 20th century, it is suggested by epidemiological studies and associated meta-analyses that long term consumption of diets rich in plant polyphenol provided some protection against cancers, cardiovascular diseases, diabetes, osteoporosis, and neurodegenerative diseases (Pandey & Rizvi, 2009).

Research has suggested that green tea polyphenol gives a wide variety of health benefits as it exhibits a range of pharmacological features, such as antibacterial, anti-inflammatory, anticarcinogenic, antioxidative, and antiarteriosclerotic activities. (Musial et al., 2020). Regular consumption has been associated with improved health, increased brain function, and a lower risk of chronic diseases (Cory et al., 2018; Trisha et al., 2022). However, while moderate intake is beneficial, excessive consumption of polyphenols may lead to adverse health effects, such as liver damage (Younes et al., 2018). The ideal approach for tracking polyphenol content which is a crucial indicator of the health advantages of green tea should be cost effective, high sensitivity, and accurate. The origin and kinds of tea have been identified, as well as the concentrations of certain chemical components, using a variety of analytical techniques. The method of evaluating the polyphenol in green tea should be efficient and focused on maintaining a high standard of quality at a reasonable price. Conventional techniques for determining the polyphenol content of green tea extraction, such as HPLC (High-Performance Liquid Chromatography), visible-near infrared spectroscopy (VIS-Nirs) and spectrophotometry frequently need for costly instruments (Maslov et al., 2021), skilled workers (Sanaeifar et al., 2020) for setup and data interpretation, and complicated pre-treatment (Sun et al., 2022).

As a potential alternative, FODS for polyphenol identification may be suitable and more affordable than current techniques, has the potential to evaluate polyphenol level of green tea drinks. FODS offers a promising solution for polyphenol detection in green tea, providing a more affordable, simple, efficient, and non-destructive approach. FODS is a salinity sensor that provides non-contact sensing with the green tea solution that will maintain the purity of the green tea while also maintaining consistent performance over repeated use. Therefore, the aim of this research is to evaluate the existence of polyphenol content in various green tea types using Fiber Optic Displacement System. Specifically, the objectives of this study are to evaluate green tea polyphenol level for Kyoto Sencha, Matcha, Genmaicha and Gyokuro green tea using Fiber Optic Displacement Sensor and to analyse Fiber Optic Displacement Sensor performance in terms of sensitivity, linearity, limit of detection (LOD) and limit of quantification (LOQ).

MATERIALS AND METHODS

Approximately 5g of crushed green tea is prepared from four different types of dried green tea which are Kyoto Sencha, Matcha, Genmaicha and Gyokuro. A methanol from is used as a solvent, and a Folin-ciocalteu reagent are obtained from ChemAR and Chemiz respectively. A stock solution of green tea is prepared by adding 100 ml amount of 70% methanol to 5g of crushed green tea. The preparation continued by vortex mixing the solution by 30s and keeping the mixed solution in a water bath at 70℃ for 10 minutes before a filtration process. A 15 ml working solution of 2124 ppm of desired concentration of polyphenol EGCG is prepared by mixing a 3 ml stock solution with distilled water. Principally, the experiment approach started with the development of the FODS experimental setup as shown in Figure 1 to study the effect of displacement between the fiber probe and the sample solution, towards the output voltage. The set up consists of a red diode laser source of wavelength 660 nm, bundled optical fiber probe of 1TF:16RF, an automated translation stage, a silicon photodetector and a computer that handles software functioning to control the probe displacement. All this equipment was all connected to a power source and is assembled as shown in Figure 1.

Figure 1 below shows an applied procedure for FODS experiments for polyphenol evaluation. An optically bundled fiber probe that consists of TF and RF is attached to the displacement arm of the controller. Red laser of 650 nm is used to emit light due to its efficiency and linearity, also having a suitable wavelength for the green tea solution. The TF is connected to the red laser source, allowing the light emitted to travel along the TF to the end of the fiber bundle to illuminate the liquid meniscus. The green tea liquid sample acts as a virtual concave mirror with a behavior that allows light reflection. The reflected light from the liquid sample is subsequently collected by the 16 RF, which maximizes light collecting due to its concentric arrangement surrounding the TF as shown in Figure 1. The light signal captured by the photo detector is then converted into an electrical signal and displayed in a waveform by the oscilloscope. The oscilloscope is set to detect peak generated by the sample reflected light signal. The intensity modulation-based displacement is controlled by the automated controller software. Overall, the effect of light signal is influenced by the displacement element applied in this FODS application. The voltage reading for all different green teas with variation of concentration is observed and collected for further analysis.

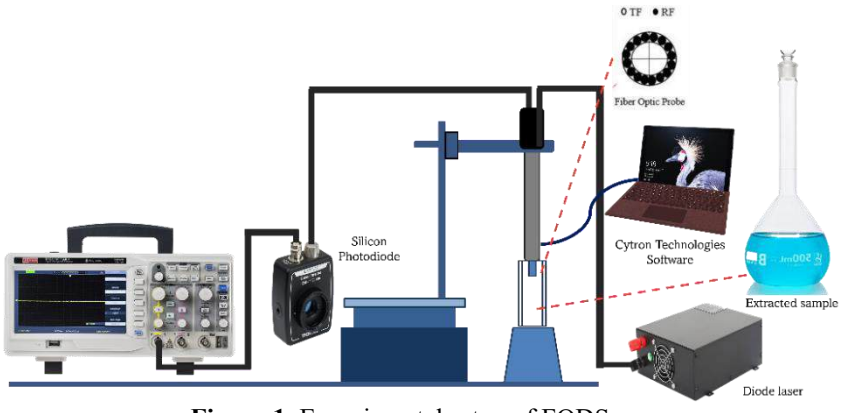


Figure 1. Experimental setup of FODS

RESULTS AND DISCUSSION

A linear calibration curve of voltage vs concentration of polyphenol was developed to analyze the trend of polyphenol levels among all four types of green tea which are Kyoto sencha, Matcha, Genmaicha, and Gyokuro. A sample at 2124 ppm is analyzed using FODS and UV-Vis. The calibration curve was constructed by plotting the voltage output of the sensor against known polyphenol concentrations and served as a tool to evaluate the sensor's sensitivity and precision in detecting polyphenol. It was specifically used to measure and compare the polyphenol levels across different types of green tea, all prepared at the same concentration. Furthermore, the concentration of 2124 ppm is selected for calibration due to its ability and suitability of concentration for absorbance analysis. This approach facilitated direct comparison between the performance of the FODS, and the results obtained from UV-Vis absorbance analysis.

Error! Reference source not found. illustrates a voltage s ignal as a function of displacement for all green types at 2124 ppm. The sensor exhibits a voltage signal that varied by the changes of displacement of fiber probe to the sample. At this concentration of 2124 ppm, Matcha green tea indicates a voltage signal of 1.92 V, meanwhile the highest voltages are indicated by Kyoto Sencha with 2.04 V peak output voltage. The first peak voltages illustrated by each sample can be observed at a displacement between 0 mm to 0.4 mm and the result is the best indicated in between 0.1 mm to 0.116 mm. As for the second peak, it can be observed at a displacement between 0.8 mm to 1.4 mm. Therefore, the output voltage is seen in the range of 0.9 mm to 1.05 mm of the displacement and the result is found to be the best in this distance range. The second peak output voltages indicate a wide difference in reading with difference of 0.68 V. Meanwhile, the first peak output voltages indicate a difference of about 0.16 V. Also, the second peaks voltages display a variant in shapes, believed to be the result of sensor vibration. Linear ranges are from -0.008 to 0.068 mm (front slopes) and 0.096 – 0.42 mm (back slopes).

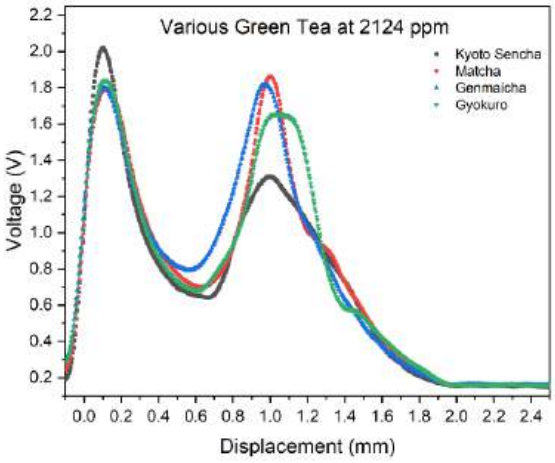


Figure 2. Sensor fingerprint as a function of displacement of 2124 ppm concentrated green tea polyphenol

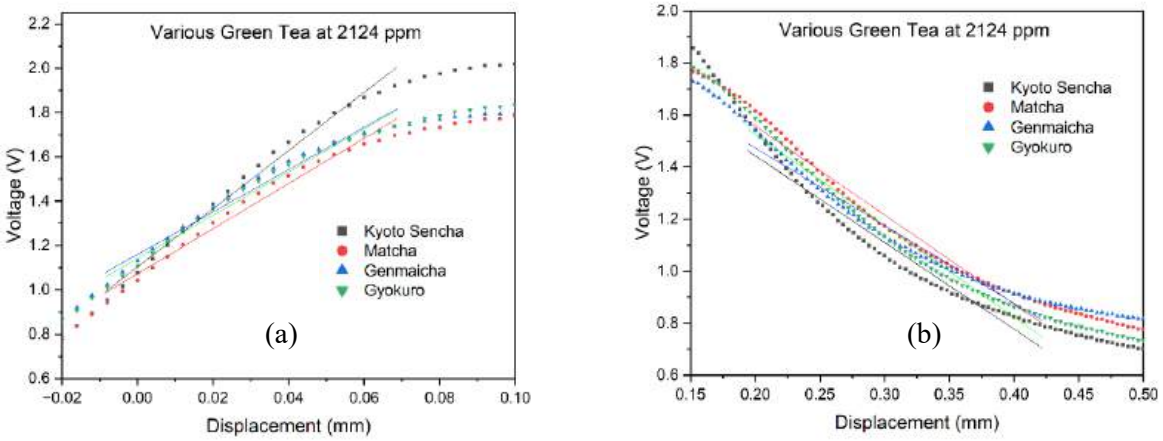


Figure 3. A linear range of polyphenol at 2124 ppm; (a) front slope (b) back slope of a first peak voltage

Table 1. The slopes efficiency for each green tea type

Green Tea at concentration 2124 ppm	Front Slope		Back Slope	
	Sensitivity (V/mm)	Linearity (%)	Sensitivity (V/mm)	Linearity (%)
Kyoto Sencha	13.1306	99.33	-3.3337	95.63
Matcha	10.1877	98.75	-3.4207	97.39
Genmaicha	9.5688	98.33	-2.9841	96.78
Gyokuro	9.7533	98.6	-3.5174	97.41

From Figure 3 (a), (b) and Table 1, it can be interpreted that drastic change occurs within a displacement before a peak value and drops gradually after the peak value. Such configuration explains that the sensor is more sensitive and significant at the front slope compared to the back slope. The change in sensitivity of the front slope for different green tea is more pronounced, whereas the back slope is less significant due to its sensitivity to the sensor is very close to each other. Thus, the fiber optic sensor is more sensitive when the displacement is less than 0.1 mm. Beyond the optimum displacements, the fiber optic sensor is less sensitive. To conclude, the performance of the fiber optic sensor in this stage is very dependent on the displacement.

Therefore, a linear curve of peak voltage vs green tea type is obtained from the peak voltages recorded. The peak voltages from each green tea types from Figure 4 below are plotted against its corresponding green tea at 2124 ppm. As indicated in this figure, Kyoto Sencha has the highest peak voltage followed by Gyokuro, Genmaicha and Matcha. From this data, it can be said that Kyoto Sencha has the highest polyphenol concentration among all the other green tea types, indicated by having the highest peak voltage value. From this FODS evaluation, the sequence of polyphenol level in terms of green tea types is led by Kyoto Sencha, followed by Gyokuro, Genmaicha and Matcha. The performance of fiber displacement sensors towards green tea polyphenol level at 2124 ppm is all stated below in Table 2.

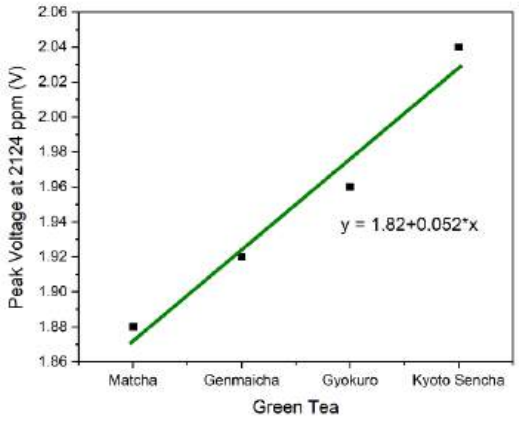


Figure 4. Peak voltage as a function of green tea types at 2124 ppm

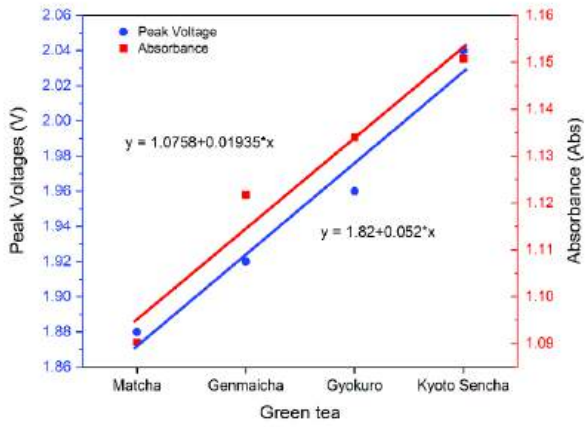


Figure 5. Comparison of linear calibrations between peak voltages by displacement sensor and absorbance by UV-Vis for green tea at 2124 ppm

Table 2. The features of fiber optic polyphenol detection on different green tea at 2124 ppm

Parameter	Value
Sensitivity (V/mm)	0.052
Linearity (%)	96.57
Dynamic range (V)	0.16
Limit of Detection, LOD (V)	4.335
Limit of Quantification, LOQ (V)	13.1365

Table 3. Absorbance of the green tea at 2124 ppm

Type of green tea	Absorbance (Abs)	Gallic acid concentration ($\mu g/ml$)
Kyoto Sencha	1.1507	181.94
Matcha	1.0903	174.29
Genmaicha	1.1217	178.27
Gyokuro	1.134	179.29

Table 3 shows the absorbance of the green tea extract of 2124 ppm based on Ultraviolet-Visible Spectroscopy (UV-Vis) at 765 nm. From Table 3, it can be observed that the Kyoto Sencha green tea has the highest absorbance. According to Beer Lamberts Law, the higher the absorbance of a sample, the higher the concentration (Mayerhofer et al., 2019). As discussed, the higher the gallic acid concentration, the higher the polyphenol indicated for a sample of green tea. As by the literature of EGCG level we use for this study, the level of EGCG is also increasing with the increment of Gallic acid. In this case, the higher the concentration, the higher the polyphenol level equivalent to the gallic acid calibration. Figure 5 indicates the similarity between the displacement sensor and UV-Vis analysis in terms of analyzing green tea polyphenol level at 2124 ppm where the linear graph of absorbance of all green tea plotted in the sequence of increasing absorbance indicated by four green teas. Therefore, Kyoto Sencha is found to be the most concentrated green tea in terms of polyphenol followed by Gyokuro, Genmaicha and Matcha green tea and it proves the calibration gain for this study from Figure 5.

CONCLUSIONS

The first objective of this research is to evaluate green tea polyphenol level for all four green teas using is achieved. The concentration of 2124 ppm of green tea polyphenol can generate the peak of output voltage. For FODS evaluation, Kyoto Sencha has the highest peak voltage range, followed by Gyokuro, Genmaicha and Matcha. Peak voltages of all four green tea types at 2124 ppm have been studied and proven that it can detect polyphenol, similar to the UV-Vis spectroscopy analysis trend on the absorbance. The performance of this linear calibration is 0.052 V/ppm for sensitivity, linearity of 96.57%, LOD of 4.335 V and 13.137 V for LOQ. They indicate the same trend where the level of polyphenol evaluated using FODS and UV-Vis spectroscopy is increasing in concentration of EGCG begin Matcha, Genmaicha, Gyokuro and Kyoto Sencha. The findings of this study indicate that the sensor can discriminate against the green tea polyphenol level, opening opportunities for polyphenol evaluation and research that requires minimal cost and complexity.

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