A Review on Pesticide Monitoring System for Fruits and Vegetables using IoT

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Abstract - *Using photo-sensitive effect and the Internet of Things, a unique non-destructive method for detecting pesticide toxicity in fruits and vegetables has been devised. As a result consumers will have confidence in the food's safety. To a portable, effective, accurate and user-friendly solution to this problem is Safe greens it is a user-friendly device that comes in a mobile phone. The app was created to assist customers in choosing the best products, fruits and vegetables of high quality. This is a new way of looking at things. Pesticide in fruits and vegetables can be predicted. The general population will benefit from the solution. This will be beneficial aid in the improvement of the general public's health. As a result, the digitalization process will be accelerated. This technology combines the Internet of Things (IoT) and mobile technology.*

Key Words: **Internet of Things, mobile technology, photo-sensitive effect.**

1. INTRODUCTION

Food processing is one of India's greatest industries, and it is a vibrant business that has grown in recent years. Fruits and vegetables are solely recognized for their freshness and quality, not for their distinctiveness. Pesticides, flavoring agents, and other unwanted substances ripening agents are used to increase the quality of fruits and vegetables, as indicated by the producers, and these ripening agents cause some major health concerns, with cancer being one of them. Consumers should learn whether or not the fruits and vegetables they choose are safe to eat. As a result, a smartphone application that determines the pesticides sprayed on fruits and vegetables can be developed to handle this issue technologically. Sensor-enabled IoT technology is used to determine the chemical components found in fruits and vegetables. This will hasten India's digitalization, and customers will profit immensely because the entire process is carried out using non-destructive technologies. To aid consumers in determining the harmful pesticide levels in fresh vegetables and fruits, we developed an IoT-based non-destructive technology kit with a mobile phone.

Supermarkets will be able to critically evaluate of fruits and vegetables and present incentives for fresh vegetables that are towards the end of their life cycle, minimizing times and increase profit, in partnership with fruit and vegetable integrators and suppliers. The quality detector will allow fruit and vegetable processors and exporters to evaluate their sources and organize their supply and delivery activities. They will then be able to receive high-quality items, which will reduce waste and prevent loss. Quality and health officials will benefit greatly from the quality detector since they will be able to access the wholesomeness of fresh vegetables during examinations using the portable scanners, guaranteeing that strict guidelines of fruits and veggies are maintained across the country. And because the tool becomes portable, food and safety officials will be able to evaluate more businesses and verify quality.

To assure quality and consistency, the physiochemical contents of foods are determined. Both destructive and non-destructive processes are used to evaluate of fruits and vegetables. Fruit and vegetable texture and hardness are assessed using destructive procedures such as permeation, pressure, and shear forces. We employ non-destructive electrical, magnetic, spectroscopy, and vibratory techniques to assess the qualitative features of fruits and vegetables.

Near-infrared reflectance spectroscopy can be used by Non-destructive Analysis to analyze the quality of foods. The partial least square regression and principal components regression techniques are used to classify Principle Components, which increases performance time and complexity. A NIRS and semiconductor array spectrophotometer with a precision of 82 percent is used to detect the quality and pesticide levels. Chemical residues and vegetable quality are thought to be best determined using electrical conductivity. The data are calculated using the PH detector, LDR, thermistor, and TDS sensor. Agrochemicals can be identified in the ground using acetylcholinesterase (AChE) biosensors. The data is delivered to a centralized processing unit, which processes it before sending the final result to the region in the format of a QR code. A QR code indicates the pesticide residue level. Damage methods use a variety of chemical components to identify the quality of fresh fruits and vegetables. We built consumer-friendly and portable techniques to keep fresh food quality.

1.1 Methodology

Pesticides can be analyzed using Gas Chromatography (GC) with ion trap mass detection, flame ionization detection, nitrogen-phosphorus detection, and Liquid Chromatography (LC) with UV, diode array, laser, or electrochemical detection. However, because of the ambiguity of food samples, these methodologies may lack the specificity and/or responsiveness required to meet residue analysis requirements. GC and LC combined to mass spectroscopic, approaches specifically tandem mass spectrometry have largely overtaken these approaches.

Thin layer chromatography is indeed the easiest alternative for pesticide analysis in situations when GLC and HPLC are not feasible. Thin layer chromatography, such as the widely used GLC, will not be used to examine materials of uncertain origin or screen for unknown compounds on its own. When working with market commodities like cabbage and many other vegetables, thin layer chromatography does have virtue of being a low-cost method. Thin layer chromatography, as a result, can be used in more isolated regions with unreliable electrical sources or a scarcity of trained employees in other, more intensive processes.

Capillary Electrophoresis (CE) is one of the most intriguing analysis techniques for the quick qualitative and quantitative examination of molecules with a wide variety of charges and molecular mass, including tiny molecules such as amino acids as well as big macromolecules such as proteins and nucleic acids. CE has emerged as a feasible alternative to the extensively employed HPLC and GC for pest management because to its versatility and excellent separation efficiency.

In 2003, Anastassiades and colleagues created the QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) process to extract pesticides from fruits and vegetables. This method was established as a low-cost, environmentally sustainable, and user-friendly alternative to meeting the growing needs of multi-residue analysis while preserving quick recovery and reproducibility. A liquid barrier with an organic liquid is used in the QuEChERS method, which is succeeded by a scattering SPE for cleanup. Many laboratories throughout the world have embraced it, and the Association of Authorized Analytic Scientists provides official techniques.

Colorimetric sensors are a viable choice for overcoming the contamination measurement conundrum. They're easy to create in general, and the signal may be seen with the bare eyes in a matter of seconds. Nanoparticle-based colorimetric sensors (NPs) are now becoming extremely tempting for the detection of numerous risks due to their intriguing capabilities, such as large absorption rate, high surface area, and localized surface plasma resonance (LSPR). When the target analyte is added to the NPs solution, the LSPR fundamental absorption shifts, as well as modifications in color and aggregate size. Based on the particular physicochemical features of NPs, a plethora of AuNPs colorimetric detectors for highly sensitive monitoring have been developed.

2. LITRATURE REVIEW

Aradhana B S and Aishwarya Raj [1] has proposed the methodology which is the integration of 3 modules. It detects pesticide residue in both fruit and vegetable. At first the fruit recognition frame work using CNN is proposed. It uses fruit size, color and texture to recognize each picture. The webcam will capture the image of the fruit and vegetable that is used. RGB image of the sample is then compared with the dataset that already containing 90380 different fruit and vegetable images and identifies the sample. The first module has the IR sensor which detects the quality of the sample. The second module has the ethyle gas sensor which is used to detect whether the fruit is ripened using the artificial ripening agent or not and the last module has the LDR sensor that detects the pesticide residue using NDVI method. The sensors in the experiment had already assigned the threshold value. the obtained experimental values are then compared with the threshold value. If the obtained values are greater than the threshold value then the LCD displays REJECT which means that the sample fruit or the vegetable has pesticide in it.

Shengan Wang, Taota Mu [2] proposed a system which detects the pesticide using nano SERS (Surface Enhanced Raman Spectroscopy) chip integrated with a smart phone-based Raman sensor. The system consists of SERS chip, adaptor, SERS terminal. Initially the sample is diluted in acetonitrile to 10ppm. In the system the chips are inserted in a 15 mm wide slot, which is of 10 mm and 8.7 mm focal length and work distance respectively. The system is built in such a way that the laser can just focus on the surface of the chip. The trace amount of diluted solution is then placed on the SERS chip and then the Raman signal of each pesticide present in the sample was collected after the solution is dried. The size of the SERS base is about 10ppm. After the process is completed, the chip can be directly removed. IN this method 12 different pesticide molecules can be detected which includes flusilazole, metalaxyl, hexaconazole, fludioxonil, dimethoate, acetamiprid. This chip is inserted into the SERS terminal and by mobile application, the measurement of the pesticide residue can be detected.

Hyeok Jung Kim and Yeji Kim [3] has developed the system to detect pesticide in the sample using colorimetry i.e detection of pesticide using colors. The proposed system uses paper microfluid device which has the hydrophobic barriers by which the analytics having fluids can pass through hydrophilic channel and ensures the sensing performance as the flow reaches the analytic reagents. In this method through lateral flow assay (LFA) based microfluid device, Organophosphate pesticides are probed as analytes. Paraxon and trichlofron are detected by the inhibition of acetylchlinesterase. Indoxyl acetates are used as a chromogenic substrate by the sensors which develop blue color when the inhibitor is not present. To develop blue color from yellow color, another chromogenic agent indophyenyl is used in LFA paper. For the detection of profenofosa and methomyl another yellow color based LFA sensor is used. In order to enhance their stability and sensitivity, the sensors are manufactured using chitosan gel mixture and forerunner of the chromogenic substrate. By the competitive inhibition reaction between the pesticide and the reagent, the pesticide in the sample is detected using three-dimensional paper. This multi-layered paper device permits for the quick and easy way to detect the pesticide in the sample and it is also easy to dispose. Further, it can make use as the suitable sensor for first screening detection of the pesticide in fruits and vegetables.

M Villar Navarro and Miguel A Cabezon [4] has developed a process called concurrent determination of pesticide in fruits by using second order fluorescence data resolved by unfolded partial least squares which are combines to residual bilinearization. For the concurrent determination of the natural fluorescent pesticides, carbaryl, carbendazim and thiabendazole in orange and banana, a chemometric aided spectroflurimetric method has been developed. For sample pre-treatment, methanol is utilized. Through second order multi-variant calibration method, emission excitation fluorescence matrices were procured and settled. This is derived from unfolded partial least squares merged with the residual bilinearization to accomplish second order benefits. In this way, even in the presence of inner filter effects, background interplay, powerful spectral overlapping, pesticides are determined in fruits. By statistically comparing the results of real sample with those procured by using HPLC.LODs of 0.038, 0.054, and 0.018 mg.kg-1 and 0.044,0.072, and 0.020 mg.kg-1 were obtained.

Fabio Leccese and Cagnetti Sabino [5] has proposed a system called electronic nose for pesticide detection. It consists of parallelly working commercial gas sensors. Based on their availability on the market, the set of sensors were selected. Two dynamic sensors have been inserted in a specific electronic card to make them agreeable and all are placed in a motherboard. Next to transmit toward internet, the electronic node is provided with acceptable communication interface. To drive a COTS card, characteristics of the sensors are trialed using Lab view SW. Collecting data from the sensors and concurrently managing the gas flow into the test chamber through a series of pumps and solenoid valves are assured. The preliminary qualitative test was conducted and a measurement bench was released and the sensor responses to different gases are depicted by first test. Different behavior of different transducers is spotted in the next step. Lastly the responses of different gases are discriminated by gathering measurement algorithms and to locate pesticides.

Deepali Gupta and Balwinder Singh Lakha [6] has proposed a system that detects the pesticide in given vegetable sample using sensors, electrical conductivity and pH. Initially vegetable samples are cleaned and the juice is extracted from it. The fixed amount of distilled water is mixed with the obtained vegetable juice in order to prepare the solution. Then the solution is added with few drops of chloropyrifos is and wait for 2 minutes. After that, different samples of vegetable at ambient temperature are used to evaluate pesticide using three different sensors for by varying the amount of pesticide in solution. This method is implied for pesticide free samples. Now application of the method on pesticide containing sample is done. Obtained vegetable sample and distilled water is mixed to prepare the solution. After that the same steps are carried out as used for pesticide free samples. At-last the graph is plotted with respected to pesticide concentration by considering the comparison results obtained from both the experiments. If the LCD display "Normal", it means the compared result show less variation with reference value, if not the LCD will show "Impurity is detected".

Tejkanwar Singh and Mandeep Singh [7] has developed a hand-held device for pesticide detection using NDVI. In this paper they designed a circuit in which a number of sensors can be interacted with it, so that the average value of the subject is obtained. Initially power circuit is constructed with the output voltage of 5V to the microcontrollers, LCD and sensors. The microcontroller is interfaced with 2 IR sensors and the photodiode which performs the function of transmitter and receiver respectively. Next the filter circuit is made in such a way that it amplifies the received input from the IR circuit. The distortion free microcontroller receives the amplified output. The ADC in the microcontroller converts the analog input signal and the formula: NDVI = B-A/A+B is used to calculate the NDVI. Then the graph is plotted for NDVI values of organic and inorganic subjects. The inorganic subject is indicated by red line and the blue line for organic subject. This both are compared and the pesticide level is detected in the sample.

Dong-kyu Lee and Giyoung Kim [8] used THz near-field enhancement method for ultrasensitive detection of pesticide. They developed a system which is highly sensitive and it is a selective sensitive tool based on the tetra-hertz (THz)- TDS system which uses nanoscale metamaterials for detecting pesticide residue. Various pesticides are tested and their THz absorbance spectrums are collected and then for the further analysis of the performance of the metamaterial sensing chip, a methomyl molecule was chosen. The nano-slot-antenna array-based THz-sensing chip is designed. At a certain frequency the chip has the strong resonance. The fruit is cut and then the THz waves penetrate the sample in few milli-meters for the examination of the pesticide residue. For this purpose, THz spectroscopy in reflection configuration is considered. By measuring the change in the THz beam reflected at the interface between the sensor chip and the sample, the amount of pesticide can be determined in the same way in the transmission configuration. The sample in cut in certain dimension and dried. After the methomyl solution was dropped on the sample, it is affixed to the nano-slot-antenna SC in order to focus THz. Terahertz wave has been continuously reflected by the sample in the time domain via a plurality of internal reflections. Based on that, two-dimensional compound distributing imaging was performed. The reflected THz image shows a clear difference between bare spots and methomyl-stained spots, effectively detecting pesticide residues.

Huang Xingjiu and Lui Jinhauai [9] proposed a system that detects the pesticide in the given sample by detecting the appearance of two pesticide gases in the sample. To perform quantitative analysis of a binary gas mixture in air, it used only SnO_2 sensor in a rectangular temperature mode. The particle size of the material is 20-50 nm, and the temperature of the sensor varies between 50-300 degrees Celsius depending on the rectangular heating voltage mode with frequencies 20MHz, 25MHz, 30MHz and 50MHz. The system features a computer-controlled mass flow controller, Teflon chamber, and multimeter. The temperature changes by modulating the heater voltage with a power supply driven by a frequency generator. The flow of compressed gas is used as the flushing gas. The test gas was standard at a concentration of 0.1 ppm acephate and trichlorophon gas. Gas sensitivity is defined as $S = R_{air} / R_{gas}$. Here, Rair and Rgas are the resistances of the sensors in air and pesticide gas, respectively. Finally, the static response of the sensor to the trichlorophon and acefate gas atmosphere, the effect of temperature on sensitivity, the effect of temperature modulation frequency on the test gas response, the effect of temperature at a constant frequency of 20 MHz is procured and from the changes in the polar plots, the concentration of the pesticide gases is procured.

Yiqun Zhu and Liangbao Yang [10] has developed a system to detect the pesticide residue at various peels using D-SERS. This method is low cost and highly efficient for the sample collection. Ag NP-decorated filter paper which is used for the precise detection and the identification of the pesticide in the sample, is the commonly used practical SERS substrate. A paper-based device is swabbed across the different surface to collect sample. Ag NP-decorated filter paper combined with D-SERS are used in the SERS experiment. The system is mainly used for the laboratory purpose.

Dr Bhandri Ranu [11] has developed a method to detect the pesticide in vegetables and fruits using QuEChERS method. In this process the sample fruits or vegetables are cut into pieces and then macerated with the grinder. A 15g macerated sample is then weighed into a 50-mL centrifuge tybe along with 30 mL acetonitrile and the mixture is shaken well for about 1 minute in a vortex shaker. Then transfer to a second centrifuge tube containing 4 g of anhydrous $MgSO_4$ and 1 g of NaCl. Shake the mixture again on a vortex shaker for 1 minute and centrifuge at 3000 rpm for 5 minutes. Next, 8 ml of this extract is placed in a 15 ml centrifuge tube containing 1.2 g of anhydrous $MgSO_4$ and 0.4 g of primary secondary amine, which is also shaken vigorously for 1 minute and centrifuged at 3000 rpm for 5 minutes Lastly a 2 mL of this extract is pipetted-out into a glass tube and the solvent is evaporated using a Turbo Vap evaporator at 30C using psi N_2 gas over 15 minutes. The detection and quantification of different pesticide compounds was carried out by injecting micro litre of the extract into a gas chromatograph with has both an electron capture detector and a flame thermionic detector. The residues are estimated by comparing the peak areas of the sample to those of the standard values under identical conditions.

Guo Zhaol and Yemin Guol [12] has developed a system for pesticide detection based on and internet of things and acetylcholinesterase biosensor. It consists of three parts: a hypogynic computer based on the AChE biosensor, and an epigynic computer based on the Labview platform and the information exchange platform. The AChE was immobilized on a working electrode and then reacted with the substrate to generate a weak current signal. The mandibular computing device collects the generated weak current signal and converts the weak current signal into a standard voltage signal of 0-5V as an output signal. You can then get the pesticide residue concentration based on the changed voltage signal. The information is then sent wirelessly to the epigenius computer. The information is set as the database and it is accessed whenever needed using the QR code.

Rohan Dasika and Siddharth Tangirala [13] has developed an effective mathod to screen the pesticide residue in fruit and vegetable sample using liquid chromatography tandem mass spectroscopy (LC-MS/MS). In this process the acetate-buffered QuEChERS sample preparation method for pesticides is applied to all samples. The solution is prepared using polytetra fluoro ethylene, triphenyl phosphate, acetonitrile, $MGSO_4$ and sodium acetate trihudrate which are added with each other and shaken forcefully for certain time and centrifuged at 4000 rpm for 4 minutes. The extract was then evaporated to dryness under a stream of argon and reconstituted with 800 ml acetonitrile / water for LCMS / MS analysis. An Agilent 1100 HPLC system was used for LC analysis. Includes binary pump, degasser, column compartment and autosampler. Applied Biosystems Analyst 1.4.2 software is used to control equipment and process data. Commercial methods from Applied Biosystems and its libraries are used to measure pesticides.

Table -1: Various Pesticide Monitoring System for Fruits and Vegetables

Various Pesticide Monitoring Systems for Fruits and Vegetables		
1)Quality and pesticide detection in fruits and vegetables.	* User friendly * Level of accuracy is high	* Time consuming * Expensive as it has integration of 3 modules
2)Pesticide detection using Nano SERES chip and smartphone- based Ramansensors	*Accurate *Good probability *High sample collection efficiency	*Expensive *More number of steps
3)Development of colorimetric paper sensor for pesticide detection using competitive inhibition reaction	*Easy to use *Easy to dispose *Fast and cheap	*Gradient color development *Sensitive performance
4)Pesticide detection using second order fluorescence data resolved by unfolded partial least squares coupled to residual bilinearization.	*Sensitive *Selective	*Suitable for laboratory Purpose only.
5)Electronic nose for pesticide detection: A first realization.	*Use of commercial sensors which are easily available in market.	* Complex architecture
6)Pesticide residue detection using EC and pH sensor.	*Quick detection *Can be used for milk and water to check impurities.	*Not so accurate
7)Hand held device for pesticide detection Using NDVI.	*Portable *Cost effective and safety	*Better sensors are needed to get less errors.
8)Ultrasensitive detection of pesticide residue using THz near-field enhancement	*Non-destructive approach *Sensitive and Selective	*It lacks quick and precise detection.
9)Pesticide detection using modulating Temperature over a single SnO2-based gas sensor.	*Rapid detection of low concentration	*Lack of stability and selectivity *Non-linear frequency time problem
10)D-SERS substrate for the detection of Pesticide residue at various peels.	*Low cost *Efficient for sample collection	*Large confocal Raman microscope is needed.
11)Pesticide residue in vegetables and fruits.	*Uses QuEchERS method. *Accurate	*Chemicals are used extensively. *Cannot be used on a day-to day basis.
12)Pesticide residue detection based on acetylcholinesterase biosensor and IoT	*Uses Internet of Things. *Information is stored as a database.	*Not so accurate *Complex chemicals are used.
13)Pesticide residue analysis of fruits and vegetables	*Uses liquid chromatography.	*Time consuming

3. CONCLUSION

Different methods of determining the grade of fruits and vegetables are included in the methodology. The presence of pesticides indicates the level of quality. Pesticide checking of foodstuffs will be streamlined by switching from numerous GC analyses to a unified GC/MS analysis. This will allow for faster examination of a wider variety of pesticide classes. For various applications, a quick, derivatization-free CE-MS approach for GLP analysis in complicated matrices was developed. Selective GLP analysis was possible because to the employment of a PVA-coated capillary with low absorption to the capillary wall and good separation efficiency. So this literature review gives insights to different methods of detecting pesticide in fruits and vegetables.

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