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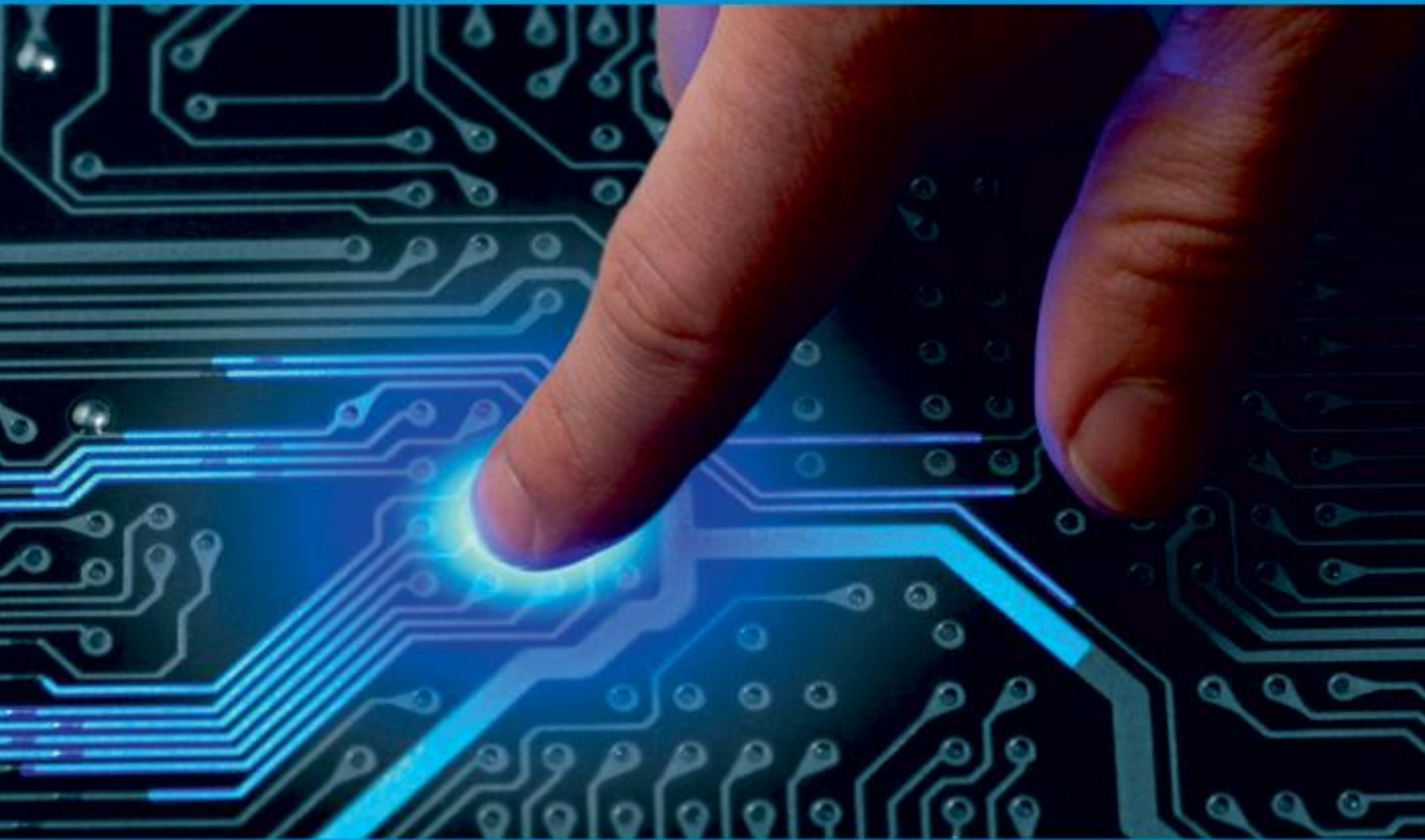

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Rotten Onion Smell Detector

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ABSTRACT: This paper introduces an assistive technology solution aimed at early detection of rotten onion, utilizing the MQ5 gas sensor module, MQ135 gas sensor module, DHT11 sensor module, ESP32s Iot development board, I2C Module for 16*2 LCD, LCD display module. Upon activation, the DHT11 sensor measures the temperature and humidity and MQ5 & MQ135 gas sensor measure the type & amount of gas released by the rotten onion, this helps in early detection of rotten onion & reduce waste. The model senses the gas and returns classification results indicating the rotting of the onion. To enhance accessibility, feedback is provided through a LED blinking, LCD displaying the message, buzzer and message on the app, with the number of beeps and messages corresponding to the identified rotting, enabling users to accurately segregate the rotten onions. Seamlessly integrating hardware and software components, the system is user-friendly and accessible for farmers, offering real-time updates and accurate classification for rotten onion identification tasks.

KEY WORDS: Assistive technology, ESP32s IOT development board, Humidity, Temperature, Gas sensing, Rotten onion identification.

I. INTRODUCTION

Rotten onions can be a breeding ground for harmful bacteria, including Salmonella and E. coli, which can cause foodborne illnesses. Detecting the smell of a rotten onion helps prevent the consumption of spoiled or contaminated food. Wasting food, especially due to spoilage, can be expensive. Detecting rotten onions and removing them promptly can save you money by reducing food waste. The motivation for detecting the smell of rotten onions primarily revolves around food safety, quality control, and consumer satisfaction. Here are several reasons why it’s essential to detect the smell of rotten onions:

Consumer Health and Safety : Rotten onions can harbor harmful bacteria and molds that can cause foodborne illnesses. Detecting the smell of rotten onions helps prevent consumers from consuming contaminated or spoiled food, reducing the risk of food poisoning.

Quality Control : Food producers and distributors need to ensure that their products meet quality standards. Detecting the smell of rotten onions is one way to identify subpar produce before it reaches consumers, protecting a company’s reputation and reducing product recalls.

II. LITERATURE SURVEY

[1] Onions are the third most valuable fresh vegetable crop in the U.S. (following only lettuce and tomato) and the second most valuable vegetable in the world (following only tomato) (National Onion Association, 2008, USDA-NASS, 2006). Almost 60 percent of non-processed onions in the nation are put in storage and consumed weeks or months later to extend the season and capitalize on a more favorable market window (Burden, 2008, National Onion Association, 2008). Normally, onions can be stored for several months with a marketable quality in a cold, dry, and well ventilated room. However, fungal and bacterial diseases affect stored onions and cause substantial losses in storage. Outbreaks of these fungal and bacterial diseases are usually caused by a few damaged and infected onions which eventually spread the pathogen and spoil to nearby wholesome onions in storage. Botrytis neck rot (caused by fungus Botrytis allii) and sour skin (caused by bacteria Burkholderia cepacia) are two major onion diseases (Schwartz

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Mohan, 2008, p. 127). Botrytis neck rot infects onion bulbs from the neck to inner layers; the sour skin usually displays the symptom with brown and water soaked main scales under the first one or two layers. Due to the nature of these two pathogens, they are virtually undetectable by human visual inspection which is a common practice in most onion packing houses. Because no effective detection methods are available, onion handlers are unaware of the presence of these diseases in the early stage until onions exhibit visual symptoms that make them unsalable at the end of the storage period. For instance, Botrytis neck rot could cause as high as 50–70 percent storage losses in some years (Boyhan and Torrance, 2002, Ceponis et al., 1986). In order to reduce postharvest losses, an effective detection technology that can identify pathogen infected onions in storage would be of great value to the onion industry. It is well known that compositions in volatile organic compounds (VOCs) may vary when fruit and vegetables experience diseases, physical damages, or physiological changes such as ripening (Simon, Hetzroni, Bordelon, Miles, Charles, 1996). One study has shown that the volatile profile from B. allii inoculated onions is different from sterile water-inoculated onion bulbs (Prithiviraj, Vikram, Kushalappa Yaylayan, 2004). An- other study proved that a gas sensor array could detect and differentiate three types of blueberry postharvest diseases by analyzing their headspace gas (Li, Krewer, Ji, Scherm, Kays, 2010). Unlike gas chromatography-mass spectrometry (GC-MS) or a human sensory panel, a gas sensor array offers an alternative method for rapid and inexpensive detection of volatile patterns. The gas sensor array, also known as the “electronic nose” (E-nose), is a chemical sensing and identification device that provides a rapid method of differentiating volatile profiles instead of identifying individual volatile compounds as GC-MS does (Mandelis and Christofides, 1993, Schaller et al., 1998). Since the invention of the E-nose technology in the early 1980s (Persaud Dodd, 1982), this concept has been studied extensively and many industrial applications of the gas sensor array already have been put into practice. For instance, gas sensor array-based technology has been used for lung cancer screening in clinical trials (Machado et al., 2005), fire and ammonia detection in spacecraft (Young, Buttner, Linnell, Rame-sham, 2003), as well as quality control in the food industry (Mielle Marquis, 2001). In particular, the E-nose was applied to an at-line monitoring and controlling the aroma during the drying process of Iberian hams in chambers (Abass Coper, 1999), as well as at-line quality sorting of spoiled sugar beet tubers (Kaipanen, 1998). This technology was also used for Allium research. The AromaScan E-nose was used to differentiate Allium species and growing conditions in the past (Abbey et al., 2001, Abbey et al., 2005). A recent study has proven that a conducting polymer sensor based E-nose could respond differently to sour skin infected onions from the wholesome onions (Li, Gitaitis, Tollner, Sumner, MacLean, 2009). Several studies have been done to identify headspace volatile compounds emitted by pathogen inoculated potato tubers and car-rots (de Lacy Costello et al., 1999, Vikram et al., 2006). To our knowledge, however, there are no reports in the literature examining volatiles in sour skin inoculated onion bulbs and little work has been done to investigate the E-nose’s capability to detect Botrytis neck rot and sour skin in onions. The overall goal of this study was to explore whether the E-nose can detect and differentiate Botrytis neck rot, sour skin, and healthy onion bulbs by measuring their headspace volatiles, as well as to characterize volatile profiles of three onion treatments by using the GC-MS. [2] Vidalia sweet onion bulbs cv. Nirvana harvested in April 2008 were used for this study. The onion samples were picked at optimum maturity when 80 percent of the necks were soft enough for leaves to collapse. Onion samples were stored in a cold room at 4 °C (R.H. 80 percent) for about 4 weeks before they were tested. Before use, dry skins were removed, basal roots were trimmed and the bulbs were surface sterilized using 1.29 × 104 mol/m3 ethanol. Onions were then washed with sterilized distilled water to remove chemical residues. Cultures of B. cepacia, strain Bc 98-4, were produced on tryptic soy agar after incubating at 30 °C for 48 h. Cultures of B. allii, strain Ba 09-1, were produced on potato dextrose agar (PDA) after incubating at 22 °C for 148 h. Bc 98-4 was stored and maintained in 2.06 × 103 mol/m3 glycerol at 80 °C. Ba 09-1 was stored and maintained on both diseased onion bulbs and PDA plates at 4 °C. A square (1 cm × 1 cm) of onion flesh was cut out with a depth of 6.5 mm using a razor blade and a similar size agar containing B. allii culture was removed from the inoculum plate and filled the hole in the onion. Every effort was made to use agar plugs of the same size which would provide a similar concentration of Botrytis for each bulb. In total, four holes were cut along the equatorial line of the bulb with equal distance. Similar physical wounds were made in control onions using a razor blade but without filling the B. allii inoculum. Sour skin inoculation was created by stabbing B. cepacia contaminated sterile wooden toothpicks into bulbs. The detailed method for sour skin inoculation was presented by Li et al. (2009). The control and Botrytis inoculated onions were stored in the air conditioned room at 24 ± 2 °C, while sour skin inoculated onions were placed in an incubator at 30 °C (the optimal growth temperature for the sour skin). B. allii inoculated onions were placed in a plastic container sealed by the aluminum foil, where a high humidity environment was created to facilitate the growth of the fungus by wet paper towels in the container. Onion bulbs with different treatments were placed in glass jars with 2 L volume and 89 mm wide mouth covered by a square of aluminum foil (100×100 mm). The contained onion samples were placed under room temperature (24 ± 2 °C) for 12 h before each measurement to allow the headspace gas to reach the equilibrium. Therefore, the temperature should not be a factor when the volatile compounds were analyzed for the three treatments. [3] Experiments were divided into two phases. The first phase was to investigate whether the E-nose could differentiate Botrytis neck rot and healthy onions; the second phase was to explore whether the E-nose could

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delineate volatile profiles from three treatments: Botrytis neck rot, sour skin, and healthy onions. In the first phase, two ex-periments were conducted in order to prove the repeatability of the E-nose. In the two experiments, 15 onions were used for control healthy onions and 15 onions were inoculated by the B. allii. Onion samples were measured on 10 and 11 dai in the first experiment, and 8 and 9 dai in the second experiment. Total 177 data sets were collected in each experiment. In the second phase, 10 onions were used for each of three treatments (control, Botrytis neck rot, and sour skin) which were measured on 5, 6, 7 dai and total 270 data sets were combined for statistical analysis. Each onion headspace was measured twice and the average of these two measurements was used as the third measurement. [4] Onion postharvest diseases cause significant losses in storage. Volatile sensing by the gas sensor array technology could be used as a promising alternative method to detect onion diseases. Onions were inoculated with Botrytis allii and Burkholderia cepacia, causal pathogen for Botrytis neck rot and sour skin, respectively. In the first phase of this study, 30 onions with equal number of B. allii inoculated and control healthy onions were measured by the gas sensor array from 8 to 11 days after inoculation (dai) and the principal component analysis (PCA) score plot demonstrated that the gas sensor array responded differently to Botrytis neck rot infected onions from those of healthy onions. In the second phase, 30 onions with 10 for each of the three treatments (Botrytis neck rot, sour skin, control) were measured by the gas sensor array on 5, 6, and 7 dai. The PCA score plot illustrated that three treatments formed three distinct clusters, while a hierarchical cluster analysis dendrogram indicated that the response of the gas sensor array to Botrytis neck rot and sour skin were similar. The correct classification rate of the linear discriminant model for three treatments was over 97.8 percent. Results from GC-MS showed that total 24 major volatiles were identified from the headspace of three treatments. Sixteen compounds were uniquely present in B. allii and B. cepacia inoculated onion bulbs. Total amount of volatile compounds detected in pathogen inoculated bulbs was one to two orders of magnitude higher than that of control healthy bulbs. This study demonstrated the feasibility of using a gas sensor array to detect two onion postharvest diseases in storage.

III. BLOCK DIAGRAM

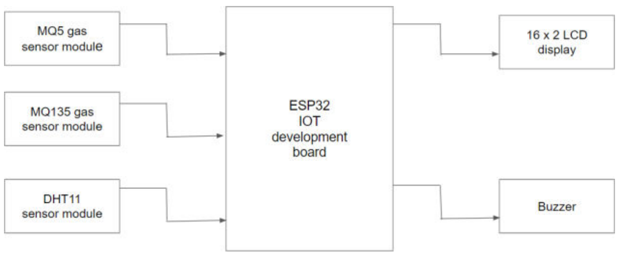

Fig -1: Block Diagram

The block diagram illustrates the architecture and components of the assistive technology system for rotten onion smell detector .

1. MQ5 Gas sensor module :
Power Supply : 5 Volts; Interface type : Analog & Digital high sensitivity to LPG, natural Gas, Town Gas & small sensitivity to smoke & alcohol ; it's cost is low . It is stable & long Life. It gives on board power indication.

2. MQ135 Gas sensor module :
Working voltage : DC 5V ; Working Current : 150mA; DOUT : TTL output ; AOUT : Analog output ;
Preheat time : Over 20s ; Dimension : 32mm x 22m x 27mm(HIGH 27mm) .

3. DHT11 Module :
The module can detect surrounding environment of the humidity and temperature . High reliability and excellent long-term stability . Output form digital output Has fixed bolt hole (3mm) and easy installation ; Humidity measurement range : 20%~90%RH ; Humidity measurement error : ±5%RH ; Temperature measurement range : 0~50°C ; Temperature measurement error : ±2°C ; Working voltage : DC5V/3.3V ; Size : approx. 30x13x8mm (L*W*H) .

4. I2C module for 16*2 LCD :
5V power supply ; Serial I2C control of LCD display using PCF8574 ; Back-light can be enabled or disabled via a jumper on the board ; Contrast control via a potentiometer
; Can have 8 modules on a single I2C bus (change address via solder jumpers)address, allowing ; Size : 41.6mm x 19.2mm .

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5. ESP32 IOT development module :

ESP32 Development board is based on the ESP WROOM32 WIFI + BLE Module. This is the latest generation of ESP32 IoT development module. This development board breaks out all ESP32 modules pins into 0.1" header and also provides a 3.3 Volt power regulator, Reset and programming button and an onboard CP2102 USB to TTL converter for programming directly via USB port. At the core of this module is the ESP32 chip, which is designed tobe scalable and adaptive. ESP32 integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, low-noise sense amplifiers, SD card interface, Ethernet, high-speed SDIO/SPI, UART, and I²C. Using Bluetooth, users can connect to their phone or broadcast low energy beacons for its detection. The use of Wi-Fi enables a large physical range, as well as a direct connection to the internet via a

Wi-Fi router. Perfect for wearable electronic or battery powered applications, the ESP32 chip uses less than 5µA.

IV. METHODOLOGY

1. MQ5 gas sensor module :

Fig -2: MQ5 Gas sensor module

This module uses MQ5 gas sensor as a gas sensing element. It requires no external components just plug in Vcc & ground pins and you are ready to go. For Digital output the threshold value can be easily set by an on-board potentiometer. Using this module you can easily interface MQ5 gas Sensor to any Microcontroller, Arduino or even Raspberry Pi. This Gas Sensor module is sensitive to Methane LPG, natural Gas & Town Gas. it is also small sensitivity to alcohol & smoke. We have Various sizes of Modules. Check out our complete collection of Modules .

2. MQ135 gas sensor module :

Fig -3: MQ1355 Gas sensor module

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MQ135 Gas Sensor module for Air Quality having Digital as well as Analog output. Sensitive material of MQ135 gas sensor is SnO2, which with lower conductivity in clean air. When the target combustible gas exist, The sensors conductivity is more higher along with the gas concentration rising. MQ135 gas sensor has high sensitivity to Ammonia, Sulphide and Benze steam, also sensitive to smoke and other harmful gases. It is with low cost and suitable for different application. Used for family, Surrounding environment noxious gas detection device, Apply to ammonia, aromatics, sulfur, benzene vapor, and other harmful gases/smoke, gas detection, tested concentration range : 10 to 1000 ppm.

3. DHT11 module :

DHT11 Humidity & Temperature Sensor With PCB

DHT11 is a basic Temperature & Humidity Sensor module with digital output at low cost. It uses thermistor to measure the surrounding air temperature and a capacitive humidity sensor to measure the moisture content. It sends digital readings on data pin so there is no need to use an Analog to Digital Converter (ADC) chip. It is very easy to use but the only problem with this sensor is that it sends data every 2 seconds. There are lot of resources online on hot to interface DHT11 Sensor to Arduino which will make this sensor easy to interface to any Arduino Board.

4. ESP32 IOT development board :

Fig -4: ESP32 IOT development board

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5. I2C Module :

Fig -5: 16X2 Character I2C LCD Module With Blue Light

All Character Modules sold on our site support 4 bit mode, and nearly all commercially available 16x2 line character modules support it too. This board has a PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display. There are many examples on internet for using this board with Arduino. Do a search for "Arduino LCD PCF8574". The I2C address is 0x3F by default, but this can be changed via 3 solder jumpers provided on the board. This allows up to 3 LCD displays to be controlled via a single I2C bus (giving each one it's own address). We have Various sizes of HMI Modules. Check out our complete collection of HMI Modules.

6. 16*2 LCD module with blue light :

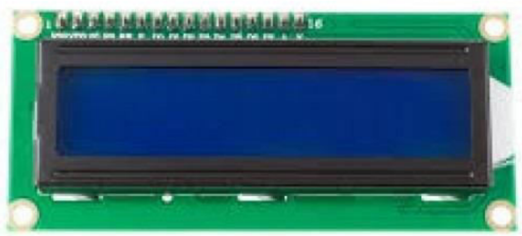

Fig -6: 16*2 LCD module with blue light

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16X2 Character I2C LCD Module With Blue Light(1602A) This 16 character by 2 line display has a very clear and high contrast white text upon a blue background/backlight. It also includes a serial I2C/IIC adaptor board pre-soldered to the back of the LCD. This 16 character by 2 line display has a very clear and high contrast white text upon a blue background/backlight. It also includes a serial I2C/IIC adaptor board pre-soldered to the back of the LCD. This means it can be controlled with just 2 I2C serial data pins (SDA & SCL) and so requires far less digital IO pins when controlled from a microcontroller. In total the module only requires 4 wires including 5V power and GND. Contrast adjustment is also provided by the daughter board via a potentiometer. These modules are currently supplied with a default I2C address of either 0x27 or 0x3F. To determine which version you have check the black I2C adaptor board on the underside of the module. If there a 3 sets of pads labelled A0, A1, & A2 then the default address will be 0x3F. If there are no pads the default address will be 0x27. The module has a contrast adjustment pot on the underside of the display. This may require adjusting for the screen to display text correctly. Note: If pressure is applied to the I2C daughter board it is possible for it to bend and come contact with the LCD module. Please ensure when the LCD is installed in your application that no external object is applying pressure to the back of the module.

V. ADVANTAGES

Early detection of spoilage helps reduce wastage for the farmer. This indirectly helps in maximizing profits for the farmer. Food Safety is another concern, many regulations need to be followed while storage and selling of food products. Quality Control is another important aspect which we can achieve with the help of this device. An onion when starts rotting, it eventually starts the rotting of another onions too when kept together . Automation is achieved with the help of this device . This device eases the life of the farmer. Automation is a crucial factor in today's world and every industry is considering automation for quality control processes. This device also increases the efficiency in early detection of rotting of onions as well as helps improve the efficiency of farmer. This device can further also be considered for cold storages as well as international markets where large amounts of essential commodities need to be stored for a larger duration, this device can prove useful in such conditions and can be designed according to the requirements ahead.

VI. APPLICATIONS

The detector can be used in food processing plants, warehouses, and supermarkets to ensure the quality and freshness of onions. By detecting the presence of a rotten onion smell, it helps prevent the distribution and sale of spoiled onions, maintaining food safety standards and customer satisfaction. The detector can be used in kitchens and households to check the freshness of stored onions. It allows individuals to identify and discard rotten onions, preventing them from being used in cooking and ensuring the overall taste and aroma of dishes. Farmers and onion growers can utilize the detector to assess the quality of harvested onions. It helps in identifying any spoiled or damaged onions, allowing for their separation and appropriate disposal. This aids in maintaining the quality of onion batches and optimizing storage conditions. Rotten onion smell detectors can be employed in waste management facilities, composting sites, or organic waste processing plants. They assist in monitoring the decomposition process and detecting any onion waste that has gone bad. This enables proper waste management practices and helps avoid odor issues and contamination. Restaurants, cafeterias, and catering services can benefit from a rotten onion smell detector to ensure the freshness of onions used in food preparation. It helps maintain the quality and taste of dishes, contributing to customer satisfaction and meeting food safety regulations.

VII. CONCLUSIONS

In conclusion, the development of a rotten onion smell detection system is a promising and innovative solution for addressing food safety and quality concerns in the agricultural and food processing industries. This system offers numerous benefits, including early detection of spoiled onions, reduced food waste, improved product quality, and enhanced consumer safety. By leveraging advanced sensor technologies and data analysis techniques, this system can effectively identify the presence of foul odors associated with onion spoilage, enabling timely intervention and product removal. It also contributes to sustainability efforts by reducing the amount of food that goes to waste, which is a critical issue in the current global food supply chain. The implementation of a rotten onion smell detection system can lead to increased efficiency and cost savings for businesses in the onion production and distribution sectors. Additionally, it fosters consumer trust by ensuring that only fresh and safe onions reach the market. Nevertheless, the successful implementation of such a

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system requires careful consideration of factors such as sensor reliability, data accuracy, and system integration. Further research and development are necessary to fine-tune the technology and adapt it to various stages of the onion supply chain. Detecting and identifying smells can be challenging, as it often requires a combination of chemical sensors, data analysis algorithms, and machine learning techniques. Specialized electronic noses or gas chromatography sensors are commonly used for odor detection and analysis in various industries and applications, such as food quality control, environmental monitoring, and healthcare. If a rotten onion smell detector were to exist, its purpose would likely be to detect the presence of spoiled onions or to monitor the freshness of stored onions in storage facilities or during transportation. This could help in preventing the distribution of spoiled onions and ensure better quality control in the food industry. The success of the project would largely depend on the effectiveness and accuracy of the detector in reliably differentiating the smell of rotten onions from other odors. It would require a robust sensor or analytical method capable of detecting specific chemical compounds associated with onion spoilage could potentially help reduce waste, improve product quality, and enhance overall food safety measures.

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