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Acidity analysis in different blackberry dilutions using IoT

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Abstract: The internet of things has expanded to all areas, including the food field, seeking to guarantee food and analyze its characteristics remotely. In this work, an electronic system is developed that allows real-time measurements and analysis of pH and temperature and controls a mixer from a mobile application. The electronic design consists of a servomotor (Mixer) and a pH and temperature sensor (pH 4502C) connected to an ESP32 board. In the experiments, the blackberry fruit pulp was used in beakers with dilutions of 25%, 50%, and 100%. The sensor probe was immersed in these samples. In the results, the experiment was performed four times so that the data were reliable; the measurement was carried out first by measuring the pH in the water for four minutes, then the sensor probe was transferred to the beaker containing the dilutions for four minutes. The pH and temperature data recorded are sent through WiFi to Thingspeak and are monitored in a mobile application designed in AppInventor, then exported the data to make decisions regarding the behavior of the pH, which allows identifying if the blackberry has the necessary conditions for humans' consumption.

Keywords pH sensor · Blackberry · ESP32 · IoT.acidity

1 Introduction

1.1 Motivation

The blackberry (Rubus glaucus) is a fruit native to tropical South America, cultivated mainly in Colombia and Ecuador [1]. It is rich in components such as anthocyanins and ellagitannins [2]. It is cultivated by farmers in the Andes region and contributes significantly to the generation of economic resources at the level of small and medium producers [3]. It has nutritional and antioxidant properties appreciated by all types of consumers for its pleasant color and flavor, as well as for its health benefits [4]. Inadequate handling, transport and packaging affect the morphological characteristics of the fruit [5,6], decreasing the content of bioactive compounds [7].

It is non-climacteric fruit rich in minerals and vitamins that requires care during harvest and post-harvest [8]. Its high moisture content (91%) makes it vulnerable to fungal attack and its shelf life is relatively short, ranging from 3 to 5 days, after which losses are close to 70% [9]. Blackberry has a fragile structure [10] and its quality decreases rapidly during the post-harvest period, which reduces its consumption in nature [11]. The pH allows predicting the quality of the food, using a colorimetric scale [12]. IoT allows the interaction of machines and their control without human interaction [13,14,15]. Through IoT, farmers can monitor factors such as humidity, health, temperature using sensors and without the need to go to the field which makes the agricultural industry more efficient [16].

1.2 Related works

In the study conducted in [17], wireless transmission technology is used with various sensors to measure temperature, pH, dissolved oxygen, water level in the fish farm. The integrated data are transmitted to mobile devices via the Internet of Things, allowing managers to monitor water quality. A robotic arm with a programmable logic controller, a chip combined with a wireless transmission module and an embedded system was developed to perform the measurements. The designed intelligent measuring equipment works around the clock, which effectively reduces data losses caused by personnel, material resources and measurement errors.

In reviewing the literature, we found a work whose objective is to implement the Internet of Things as an information system to measure and monitor moisture, pH, and NPK levels in mustard leaf crops with capillary

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irrigation and liquid organic fertilizer. For this purpose, a completely randomized design was used with two factors: the type of liquid organic fertilizer and the number of capillary irrigation wicks.

The results showed that soil moisture during mustard leaf growth ranged from 16.59% to 23.48%, the higher the capillary wick, the higher the soil moisture, the average water requirement for mustard plant growth was 3.16 liters. The application of liquid organic fertilizer has a significant effect on soil pH and NPK levels in the soil. Capillary irrigation had a significant effect on soil pH, but had no significant effect on soil NPK levels [18].

2 Design and Materials

To develop this proposal, a system on chip board is used in which the programming for the operation of a pH and temperature sensor is installed, a servo motor is included to generate movement in the blackberry fruit pulp that is in a 500 ml beaker where the pH probe is immersed. The recorded pH and temperature data are sent over the internet via an IoT platform and read into a mobile application that employs a cloud database. (Fig. 1) shows the elements used in the process.

2.1 System requirements

The requirements for the system to measure the variables and process the required information are as follows: A 500 ml beaker in which there is 350 ml of blackberry fruit pulp. The pH-temperature sensor will measure the pH [H+] and temperature [°C] by introducing the probe into the pulp. A servo motor is used to mix the pulp throughout the process. Wi-Fi connectivity is required to process the information through the System on chip board and to be linked through the IoT platform so that the information can be read through a mobile application. The system requirements can be seen in Table 1.

2.2 Circuit and Program

The project design is based on an ESP32 board to which the pH sensor and servo motor are connected. The To input is connected to pin 32, Po is connected to pin 33, G is connected to GND and uses a 3V3 power supply. Regarding the servo motor the GND input is connected to pin GND, the input for operation to pin 4 uses a 5V supply. The system design is shown in (Fig. 2).

Table 1 System Requirements

Device	Requirement Description	Required
pH sensor	pH 0-14 value sensing sensor module plus BNC pH electrode probe for value sensing sensor	pH 4502C
Temperature Sensor	Temperature range: 32.0-176.0 [°F], 0 - 80 [°C].	pH 4502C
Servo Motor	Operating speed (no load): 0.09 ± 0.01 sec/60° (4.8 V) 0.08 ± 0.01 sec/60° (6 V). Operating angle: 180 degrees	Micro Servo 9g SG90
System on chip	System with Wifi connection, analog inputs, I2C communication.	ESP-WROOM-32 for Arduino.
IoT plataform	Store, graph and process data in the cloud.	Thingspeak
App	For smartphone, portable, user menu and Android operating system.	Appinventor
Precitation Glass	1.7 fl. oz. thick low form borosilicate glass.	Precipitation beaker with 500 ml capacity.

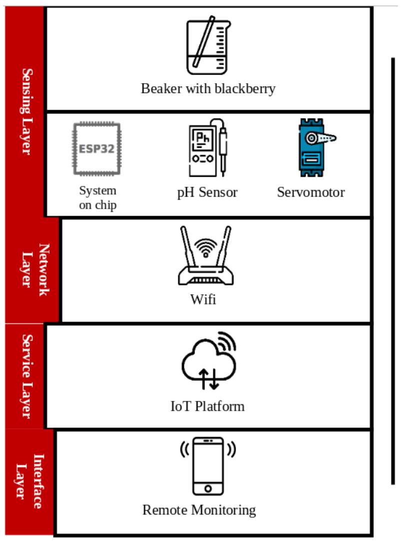

Fig. 1 IoT design for pH monitoring

For the programming of the pH and temperature sensor, Arduino is used, where three libraries are included: ESP32Servo.h, Thingspeak.h and WiFi.h, the pH input is connected to pin 33, the temperature input to pin 35, and the servomotor is connected to pin 4 (see Fig. 3).

3 Connectivity and Interface

3.1 Communication

The communication is done through the ESP32 board which has WiFi connection, the data of the measurements are processed through Thingspeak where these

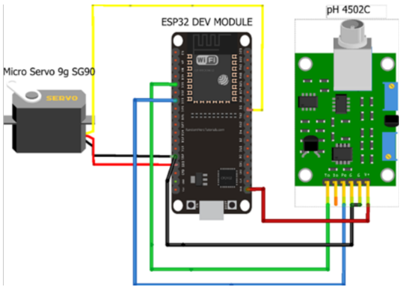

Fig. 2 Circuit Design

```
#include <ESP32Servo.h>
#include <ThingSpeak.h>
#include <WiFi.h>
WiFiClient cliente;
Servo myservo;
float calibration = 0.00+18.82+4.2;
int PinPh = 33,PinT=35, ValorSensorPh,orden=0;
```

Fig. 3 Arduino Programming Code

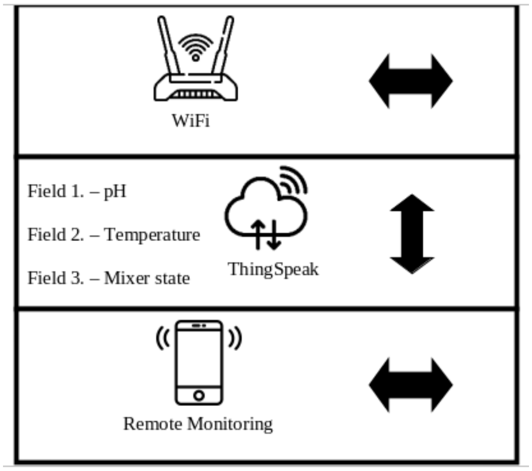

Fig. 4 System Communication

are stored and analyzed, then the data can be observed through the application made to in the Appinventor application. (Fig. 4) represents the communication of the system.

3.2 User interface

Through the Appinventor application, the user interface is designed where a button for the mixing process is shown, a section where the pH data graph is shown, the section corresponding to the Temperature graph, and a section corresponding to the pH graph. (Fig. 5) shows the user interface created for the project.

4 Analysis of Results

To analyze the results, the installation of the system was performed as shown in Fig. 6.

Fig. 5 User interface

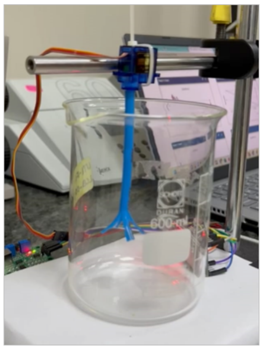

Fig. 6 System Installation

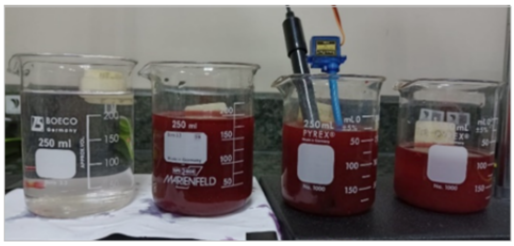

Fig. 7 Design of Experiment

The experiment was designed using four beakers; in the first one we placed water (400 ml), in the other three beakers we placed 100 ml of water and added (25%, 50%, 100%) of blackberry pulp, respectively) as shown in Fig. 7. To verify the functionality of the application, tests were performed in which a user used the application to take measurements as shown in (Fig. 8).

4.1 Data collected

The data collected by the designed application were pH [H+] and Temperature [°C] measured in blackberry pulp at different concentrations. (Fig. 9) shows the data recorded by the application for pH and temperature.

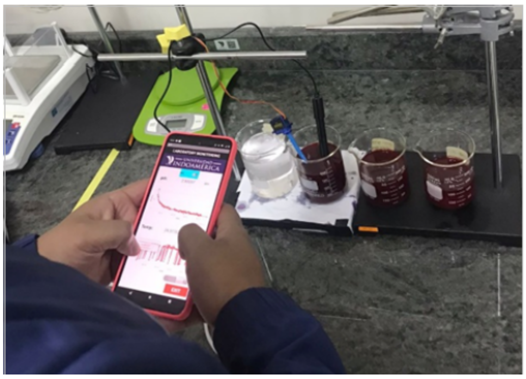

Fig. 8 Use of the Application

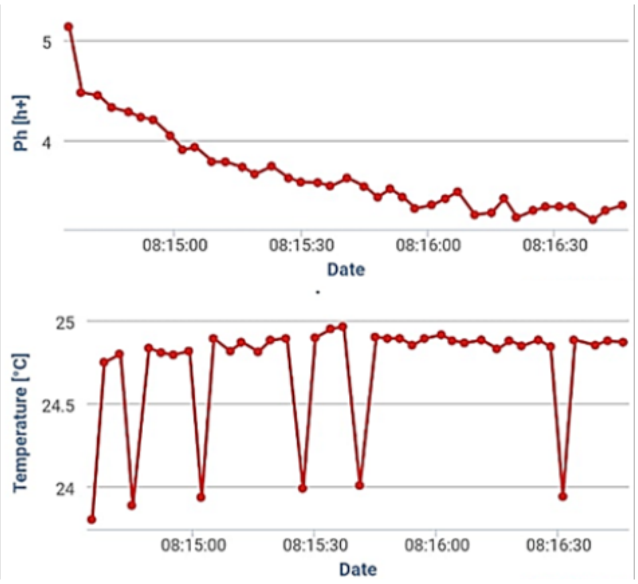

Fig. 9 Measurement of pH [H+] and Temperature [°C]

4.2 Analysis of the experiments

The data obtained were plotted through Excel, the experiment was performed four times so that there is greater reliability in the data, these were measured for four hours in total, the measurement was carried out first by measuring the pH in water for four minutes, then the sensor probe was transferred to the glass containing the 25% solution for four minutes, the pH probe is returned to water for another four minutes, this procedure is performed with the 50% and 100% solutions. (Fig. 10) shows the graphs obtained from the four experiments.

Table 2 shows the pH variations in the four experiments carried out; the pH variation in experiment 1 is 2.48% between the 25% to 50% dilutions and 0.66% in the 50% to 100% dilution. In experiment 2 is 1.87% between the 25% to 50% dilutions and 0.97% in the 50% to 100% dilution. In experiment 3, the variation in the 25% to 50% dilutions is 1.27%, and the variation in the 50% to 100% dilutions is 1.63%. Finally, in experiment 4, the variation between the 25% to 50% dilutions is 1.27%, and the variation in the 50% to 100% dilution is 1.62%, which allows determining that the sensor works correctly due to high repeatability even though different reference levels. For example, in experiment 4, the water was mixed with blackberry pulp due to the changes made from the sensor probe to the different beaker.

Table 2 Data Analysis

	Concentration [%]	pH Mean [H+]	Variation [H+]
Experiment 1	25	3.22	0.08
	50	3.05	0.02
	100	3.02	
Experiment 2	25	3.21	0.06
	50	3.08	0.03
	100	3.02	
Experiment 3	25	3.15	0.04
	50	3.06	0.05
	100	2.96	
Experiment 4	25	3.15	0.04
	50	3.08	0.05
	100	2.99	

5 Conclusions

The system assembled for this experiment has two functions that allow on the one hand to monitor the pH and temperature, and on the other to control the mixer of the environment where the system is installed. The measurements can be observed in real time through the application designed in App Inventor, the data were stored in the Thingspeak platform and then exported to Excel to make graphs and make decisions regarding the behavior of the pH, which allows to know if the blackberry pulp has the necessary conditions to be consumed. In addition, it allowed to analyze the acidity level of the blackberry with different concentration levels. As future work, it is recommended that different environments be used to monitor pH behavior, and to determine which is the most suitable for preserving blackberry pulp over time.

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Conflict of interest

The authors declare that they have no conflict of interest.

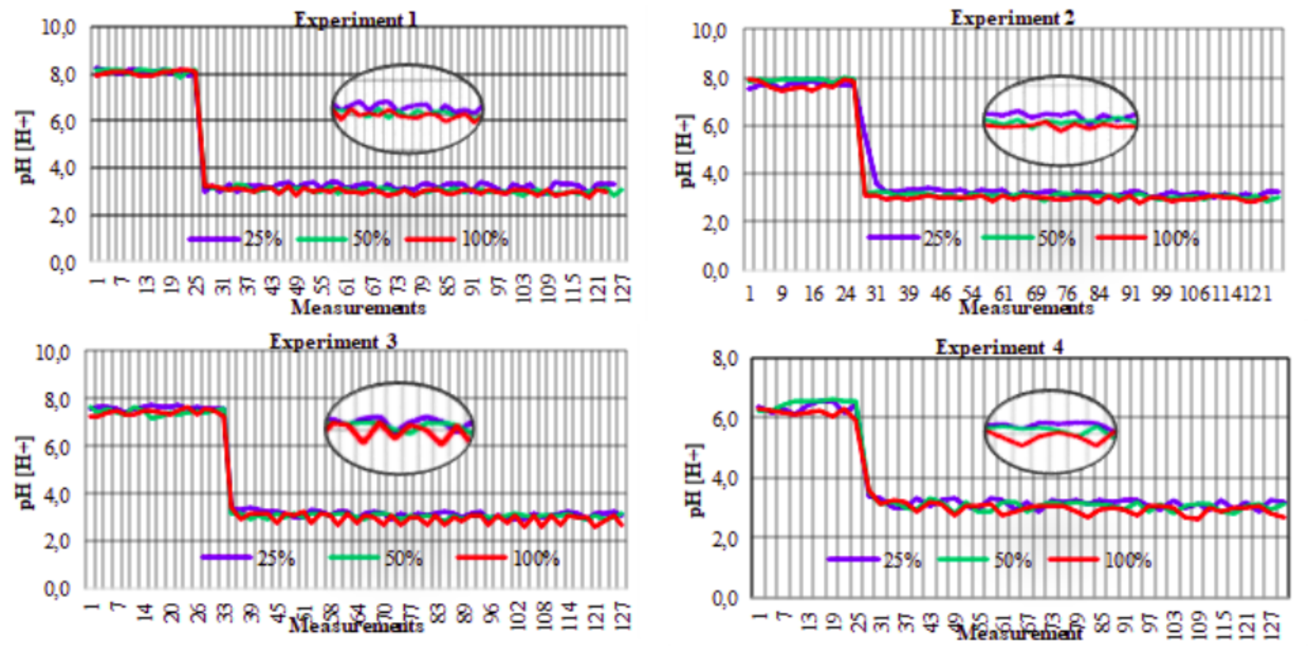

Fig. 10 pH data of the different blackberry dilutions by experiment

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