Mold-free showcase

Multiple-sensor systems control the shelf life of pastries by monitoring relative humidity, carbon dioxide, and temperature. data from multiple sensors is integrated to provide accurate prediction of shelf live and present meaningful relations between influenced parameters on microbial growth. The system is tested under stimulating bakery conditions, demonstrates reliable performance in alerting non-technical users, and prevents spoilage formation.

System overview:

The monitoring system integrates two sensors:

DHT-11: detect the change in relative humidity (%) and temperature in degrees Celsius, with the precision of 1 degree for temperature and 1% for relative humidity

MQ-135: detect the change in carbon dioxide, with the precession of 35 ppm.

Data is processed by Arduino Nano microcontroller; data is shown via the serial interface.

Data is sent to the laptop for storage by Arduino Nano cable.

Data storage:

Data is stored as a text file via CoolTerm by configuring the correct COM port that matches with value in the Arduino code.

Data visualization:

Real-time data is visualized by Python as shown in the figure:

- Indoor temperature, shown as a blue line, increased as an excess threshold which is 25 degrees Celsius.

- Relative humidity determined by indoor and outdoor humidity, shown as blue and light blue respectively, excess its threshold when relative humidity is more than 60%
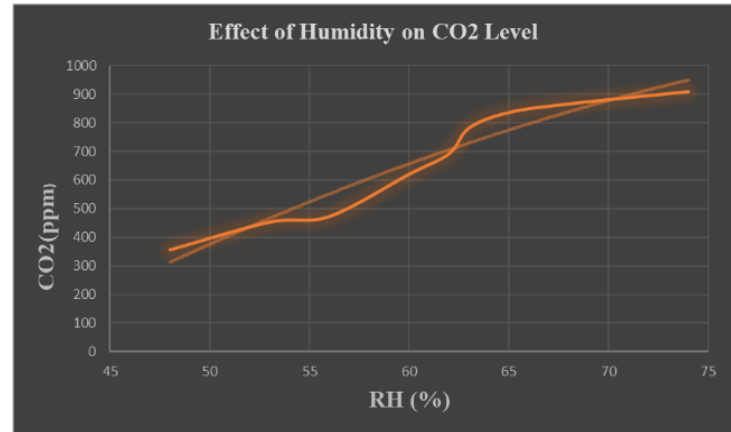
- Carbon dioxide, shown as a red line, increases rapidly as the threshold of temperature and humidity excessed.

Microbial growth activates when carbon dioxide exceeds 500ppm, the bread gets moldy when carbon dioxide exceeds 1000ppm.

Data of carbon dioxide and relative humidity is analyzed to form the following equation:

$CO_2 = -0.2998RH^2 + 61.0774RH - 1928.6582$, derived from the following graph.

Effect of Humidity on CO2 Level

(Graph: CO2(ppm) on y-axis from 0 to 1000, RH (%) on x-axis from 45 to 75)

Test performance:

Humidity and temperature change, as temperature and humidity increase, carbon dioxide level rises and excess threshold.

When the data excess threshold, 25 degrees, and RH is 60%, the first alarm is activated to alert the user of predicted mold after 7 hours.

The second alarm is activated when carbon dioxide levels exceed 1000 ppm to get away from the pastries as they get moldy.

The chosen threshold of carbon dioxide is determined experimentally, according to the number of pastries and the capacity of the showcase.