Studying Weather Data for the Development of Innovative Pepper Hybrid Drying Machine.

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Abstract

The 'Trang pepper' is a Geographical Indication (GI) product of Trang province, known for its distinctive characteristics, particularly the red pepper, which has a fragrant aroma similar to high-value fruits, and commands a high price per kilogram. Therefore, researchers conducted field surveys on the Trang pepper processing methods of farmers. It was found that weather could be one of the factors affecting pepper processing. The objective was to study weather data impacting the pepper drying process and to develop a pepper drying cabinet to control temperature and humidity. The study was conducted at two sites: Bansuan Heritage Trang Pepper and Trang Weather Station, by collecting weather data including air temperature, relative humidity, and rainfall. The results showed that the average air temperature at both sites was lower than the appropriate range for the pepper drying process (40-50°C). The average relative humidity values at the two sites were 74.4% and 78.8%, respectively. The amount of rainfall at the two sites was 1,486 mm and 1,281.9 mm, respectively. The high levels of relative humidity and rainfall could hinder the processing of pepper to achieve the desired quality. Therefore, researchers designed and developed a pepper drying cabinet considering factors such as heat distribution, heat transfer, and radiation from sunlight and heaters. The results indicated that the average temperature values ranged from 41.4-46.1°C and the relative humidity ranged from 28.8%-37.4%, which are within the appropriate range for drying. Peppers processed through the hybrid drying machine met the standard quality. This showed that the hybrid pepper drying machine can produce high-quality pepper that is acceptable to farmers.

Keywords: Pepper drying cabinet, Palian pepper, GI product, Weather data, IoT system

Research Questions

1) Does the Trang province's weather have an affect on the pepper drying process?

2) Does the developed innovation have the capability of drying pepper?

Hypothesis

1) Trang province's weather have an affect on the pepper drying process

2) The developed innovation has the capability of drying pepper, so that the pepper through the drying process have passed the standard quality**.**

Introduction

Palian pepper is an industrial crop and a GI (Geographic Indication) product of Trang Province, which is an export product that earns a lot of income for farmers, especially red pepper with has a fragrant aroma similar to high-value fruits. Therefore, red pepper costs as high as 3,000฿ per kilogram. Pepper is harvested from January to April and September to December. However, during the harvest season in Trang province, there are high levels of rainfall and relative humidity, which is not appropriate for pepper drying process. As consequently, most of the pepper product were unable to reach the standard level. The researchers field survey the pepper processing of farmers. It was discovered that small-scale farmers dried pepper using solar-heated mats. Consequently, it is challenging to drying pepper and unable to reach the standard level during rainy season or at night. The researchers were interested in studying weather conditions to develop a pepper hybrid drying cabinet that could adjust for local weather circumstances, including controlling the temperature within the range of 40-50°C and controlling the humidity for appropriate pepper drying process.

The study of weather data for the development of innovative pepper hybrid drying machine. It was a study of weather data such as air temperature, relative humidity and rain of 2 study sites: Bansuan Heritage Trang Pepper and Trang Weather Station. The data will be used to design and develop pepper drying cabinet, assessing its efficiency, and test the quality of the pepper that has been dried using the innovation.

Materials

1) Polycarbonate Sheet
2) Aluminium Sheet
3) Infrared heater 220V 1000W 2 ea.
4) Fiber Mesh
5) Caster
6) Sensor AM2305
7) NodeMCU esp8266
8) Ventilation Fan 220 V
9) Relay
10) Cut out

Methods

1) Study sites

Study pepper processing of farmers at Bansuan Heritage Trang Pepper, Yan Ta Khao district, Trang province, which located at latitude 7.40371N and longitude 99.64787E and Trang Weather Station located at latitude 7.51226N and longitude 99.62070E

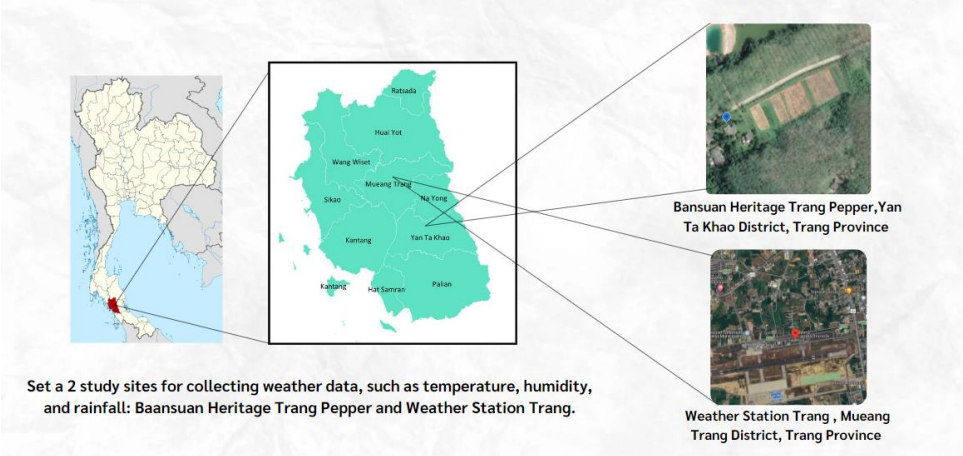

Figure 1: Shows the study sites.

2) Weather data collection

Fieldwork and weather data collection such as air temperature, relative humidity and rain at study sites according to the GLOBE method in January – December 2566 as follows.

2.1 Air temperature measurement using a digital thermometer, which is required to read the temperature at solar noon.

2.2 Relative humidity measurement using a digital hygrometer, which can determine the relative humidity directly from the instrument.

2.3 Rain measurement using Rain gauge collect the amount of rain once a day for every 24 hours. By collecting at solar noon

2.4 Send data to Data Entry

3) Development of pepper drying cabinet

3.1 Collect information about ideas, research, and technologies from various incubators.

3.2 Design an innovative draft based on the findings from the weather data analysis.

3.3 Conducting innovation

3.4 Assessing the efficiency of innovation based on 2 aspects: 1) The efficiency of pepper drying cabinet such as study of temperature inside and outside the cabinet, study of relative humidity inside and outside the cabinet and study of illuminance inside the cabinet 2) Testing the quality of pepper such as seed moisture content, weight remaining, pepper odor sensitivity, color measurement before and after drying.

4) Statistical analysis

Analyze the data by using a one-way ANOVA on Microsoft Excel

Results

1) Study of weather data

1.1 The results of average air temperature (°C) between January – December 2023 on 2 study sites discovered no significant differences in each month. The temperature at Bansuan Heritage Trang Pepper lower than the temperature at Trang Weather Station, as shown in Figure 2

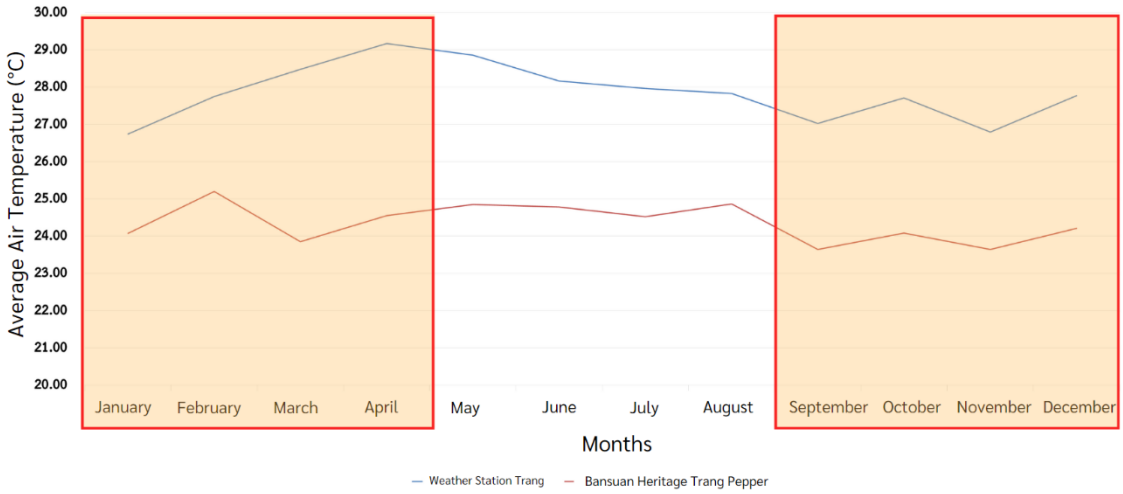

Figure 2: Shows the average temperature between between January – December 2023 on 2 study sites.

As a results, it was found that during the harvest season from January to April and September to December. The average temperature at Bansuan Heritage Trang pepper is 24.2 ℃ and the average temperature at Trang Weather station is 27.7℃, which the average temperature lower than the appropriate for drying pepper: 40-50 ℃

1.2 The results of average relative humidity (%) between January – December 2023 on 2 study, as shown in Figure 3

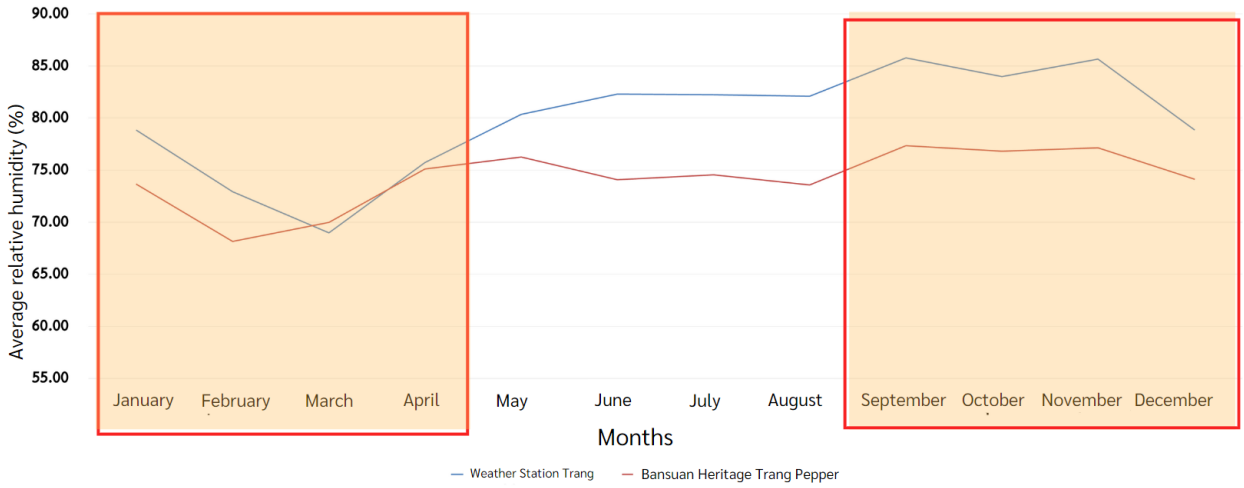

Figure 3: Shows the average relative humidity between between January – December 2023 on 2 study sites.

As a results, it was found that during the harvest season from January to April and September to December. The average relative humidity at Bansuan Heritage Trang pepper is 74.0% and the average relative humidity at Trang Weather station is 78.8%, which is high level of the average relative humidity will affect the seed moisture content.

1.3 The results of the amount of rain (mm.) between January – December 2023 on 2 study, as shown in Figure 4

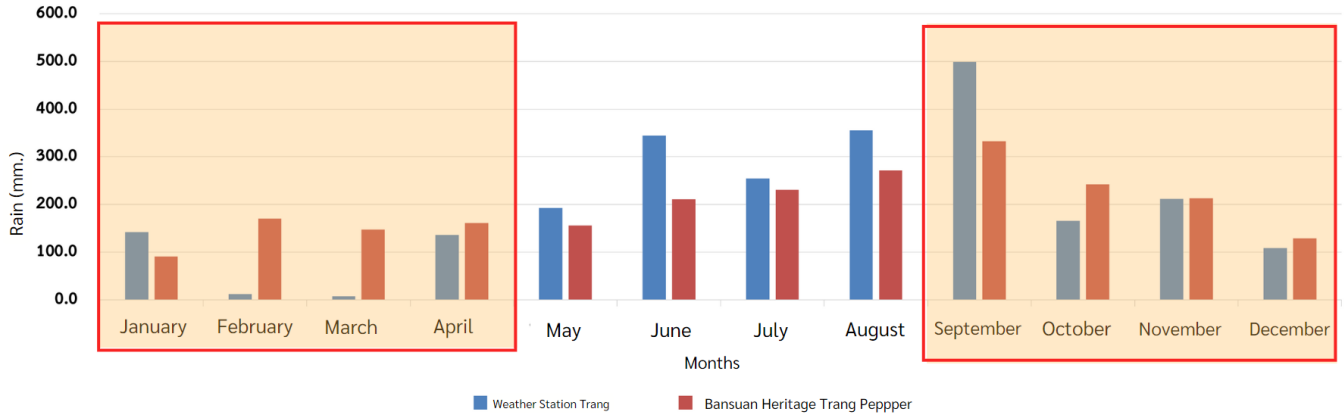

Figure 4: Shows the amount of rain between January – December 2023 on 2 study sites.

As a results, it was found that during the harvest season from January to April and September to December. The amount of rain at Bansuan Heritage Trang pepper is 1,486 mm. and the amount of rain at Trang Weather station is 1,281.9 mm.

2) Development of Innovation

2.1 Design an temperature and humidity control system and IoT system

From the research was found that the appropriate temperature to dried pepper within the range of 40-50°C and seed moisture content should less than 12%. The information leads to design the cabinet's temperature and humidity control system. Furthermore, set up the IoT system, which report the temperature and humidity on Real-Time via smartphone.

Figure 5: Shows the temperature and humidity in Real-Time via smartphone

2.2 Development of pepper drying cabinet

Normally, farmers drying pepper on mats, which requires a lot of area to dry and solely uses heat source from the sun. Therefore, researchers design and develop a tiny pepper drying cabinet for small-scale farmers. By collecting information about huge prototype cabinet from Mr. Bandit Piromthong, who was pepper farmers at Yan Ta Khao district, Trang province. It was found that to drying pepper 10 kg once a time, develop cabinet's size: 1x1x1.6 m. and required 4 layers. The distance between each layer is 30 cm. for air flows easily. The size of the cabinet rack's hole for placing pepper is 2 mm. for the hot air below flows through the hole up to the top. If the hole's size smaller than 2 mm. will against the wind and if the hole's size bigger than pepper, it was unable to placing pepper. The roof of the cabinet is slanted so that it could drained the water when it was rain. The material used to build the frame of cabinet is aluminum, which was lightweight, dislocate easily, it does not rust and reasonably priced. Moreover, aluminum's heat transfer is convenient. The wall of cabinet made of polycarbonate sheet, which is extremely flexible, filters out light intensity, scatters light, and reflects heat effectively. In addition, the cabinet installed one infrared heater to

serve as the heat source for drying pepper for 24 hours, as well as two ventilation fans to evacuate moisture inside the cabinet. The cabinet's draft is as follows.

Figure 6: Cabinet's draft

Figure 7: Shows the pepper drying cabinet

Pepper hybrid drying machine Principle

Pepper drying cabinet uses heat source from sunlight and infrared heater. When pepper drying cabinet receives heat from sunlight by radiation and heat transfer by molecules outside flows through the cabinet from below grille. The high-temperature air molecules inside the cabinet will float upward, removing moisture through a ventilation fan. Furthermore, heat radiated from the heater causes the temperature within the pepper drying cabinet to range between 40-50°C

3) Assessing the efficiency of innovation

3.1 Study of temperature and relative humidity inside the cabinet every hour, throughout a 24-hour period of each layer. It was found that no significant differences in temperature and humidity among the layers, as shown in Figure 9

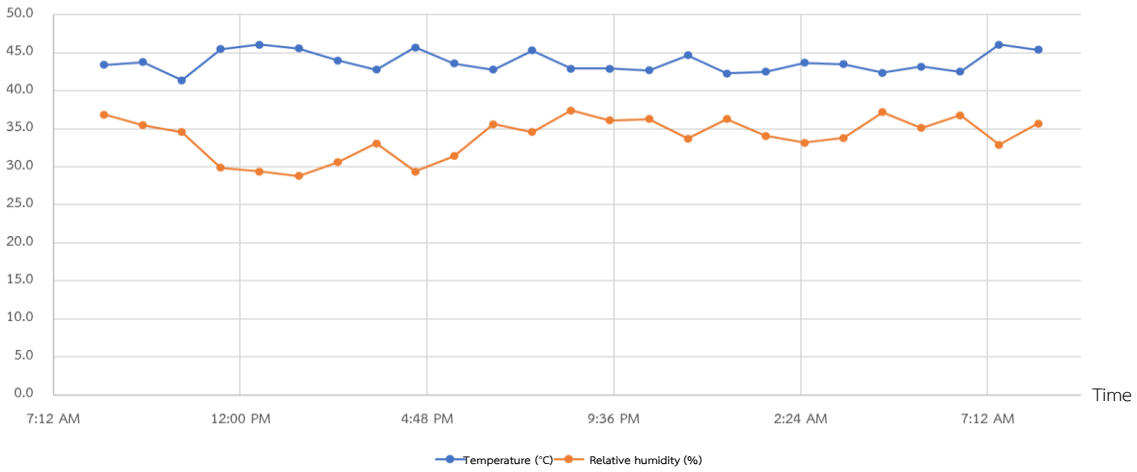

Figure 8: Shows the temperature and relative humidity inside the cabinet.

The results show that the temperature inside the cabinet within the range of 41.4 – 46.1°C and the relative humidity within the range of 28.8 – 37.4%, which is appropriate for drying pepper process. (Atchara Saekow, 2555)

3.2 Study of illuminance inside the cabinet

A study of illuminance within the cabinet every hour from 08.30 AM to 15.30 PM was found that the illuminance inside the cabinet fluctuates statistically considerably at .05 and the illuminance within the range of 1,550-4,220 lux, which is appropriate for drying pepper (Sarayut Maolee, 2564), as shown in Figure 10

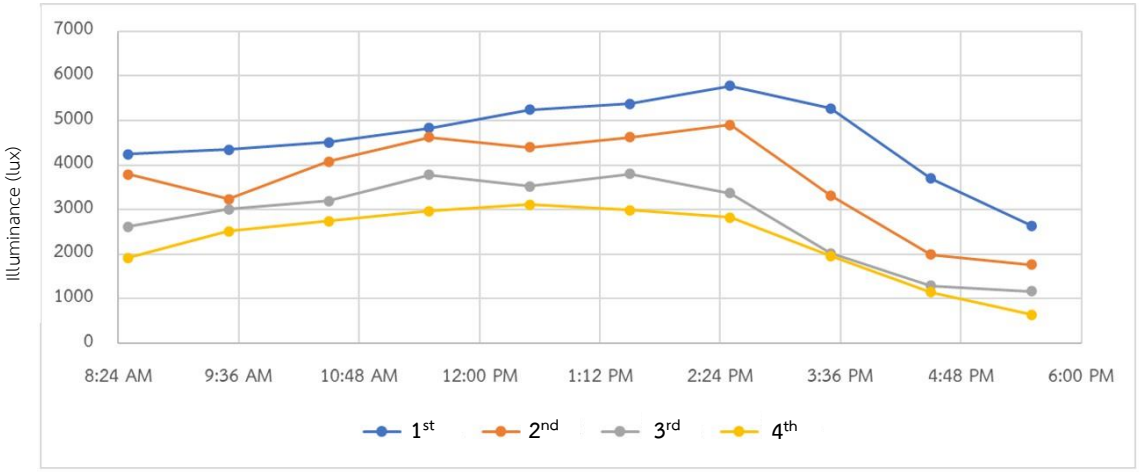

Figure 9: Shows the illuminance inside the cabinet on 1st - 4th Layer.

4) Testing the quality of pepper through drying process with developed cabinet

4.1 Color measurement before and after drying using systematic randomization, 100 pepper seeds, as shown in Table 1

Color	Color Code				
	Before drying	After drying			
		1st Layer	2nd Layer	3rd Layer	4th Layer
Green	0648	1069	1069	0908	0964
Yellow	0428	0473	0543	0542	0473
Orange	0527	0557	0557	0557	0557
Red	0556	0354	0300	0557	0312

Table 1: Shows the color of pepper seeds before and after drying

The results show that the color of the pepper after drying, green and yellow pepper are similar in shade, whereas red and orange peppers are similar in color, which

shifted to a darker shade within acceptable limits for Bansuan Heritage Trang Pepper and industry standards.

4.2 Study of weight remaining of pepper

The results showed no significant differences in each layer, as shown in Table 2

Color	Weight remaining (%)				
	1st Layer	2nd Layer	3rd Layer	4th Layer	Average
Green	41.55	41.27	41.76	39.94	41.13±0.71
Yellow	42.27	44.62	41.37	40.46	42.18±1.55
Orange	42.29	45.11	44.84	44.30	44.13±1.10
Red	45.78	45.68	46.17	44.79	45.61±0.50

Table 2: Shows the remaining weight of pepper after drying.

4.3 Study of seed moisture content, as shown in Table 3

Color	Seed moisture content (%)				
	1st Layer	2nd Layer	3rd Layer	4th Layer	Average
Green	5.9	5.8	5.7	5.2	5.7±0.3
Yellow	5.3	5.2	4.8	4.6	5.0±0.3
Orange	5.3	5.3	5.1	4.7	5.1±0.2
Red	5.8	5.6	5.5	4.5	5.4±0.5
Average	5.6±0.3	5.5±0.2	5.3±0.3	4.8±0.3	

Table 3: Shows the seed moisture content after drying.

It was found that pepper seed moisture content passed the requirements. (less than 12%)

4.4 Study of pepper odor sensitivity

A study of pepper odor sensitivity on each color: 50 g. Initially, the method of sniffing through the nose, as shown in Table 4

Color	Odor
Green	None of Berry-fragrant
Yellow	Subtle Berry-fragrant
Orange	Distinct Berry-fragrant
Red	Distinct Berry-fragrant

Table 4: Shows the odor sensitivity of pepper

It was found that red and orange pepper had a distinct berry fragrant, yellow pepper had a subtle berry fragrant, and green pepper did not exhibit a berry fragrant.

Discussion and Conclusions

The results of studying weather data for the development of innovative pepper hybrid drying machine by fieldwork and weather data collection on 2 study sites: Bansuan Heritage Trang Pepper Yan Ta Khao district, Trang province and Weather Trang Station between January – December 2023. By collecting weather data: air temperature, relative humidity and rain on 2 study sites found that during harvest season from January to April and September to December. The results showed that the average air temperature values of 2 study sites was lower than the appropriate air temperature for pepper drying process (40-50°C). The average relative humidity values on 2 study sites being 74.4% and 78.8%, respectively. The amount of rainfall on 2 study sites was 1,486 mm. and 1,281.9 mm., respectively. The large amounts of the relative humidity and rainfall can cause to the processing of pepper to achieve the desire quality.

Therefore, researchers design and develop a pepper drying cabinet to solve a pepper drying process issue for farmers. By design the cabinet's temperature within the range of 40-50°C and humidity control system and seed moisture content should less than 12%. Furthermore, set up the IoT system, which report the temperature and humidity on Real-Time via smartphone.

The results of design and develop pepper drying cabinet's size: 1x1x1.6 m. The material used to build the frame of cabinet is Food grade aluminum. The wall made of poly

carbonate sheet, required 4 layers uses heat source from sunlight and infrared heater for drying pepper, including ventilation fan for evacuate moisture inside the cabinet. The results found that the temperature inside the cabinet within the range of 41.4 – 46.1°C and the relative humidity within the range of 28.8 – 37.4%, which is appropriate for drying pepper process. The illuminance inside the cabinet within the range of 1,550-4,220 lux, Testing the quality of pepper through drying process with developed cabinet found that the color's pepper shifted to a darker shade within acceptable limits for industry standards (Bandit Piromthong). The pepper seed moisture content within the range of 4.6-5.9 passed the requirements. (less than 12%). The remaining weight of the pepper seeds after drying in each color (green, yellow, orange, red) was more than 40%, This remaining weight was higher than that of pepper from conventional drying processes (33% of pre-drying weight). Meanwhile, the green pepper has the lowest remaining weight due to the least sugar content of the pepper seed, as opposed to the red pepper, which has the largest amount of sugar and thus the highest remaining weight. In terms of aroma, red and orange pepper had a distinct berry fragrant, yellow peppers had a subtle berry fragrant, and green peppers did not exhibit a berry fragrant. Pepper smells like berries since it is derived from the same species. Red and orange peppers have more volatile oil than green and yellow peppers, therefore they smell more clearly. This demonstrates that the pepper hybrid drying machine may be used to dry peppers within acceptable limits for industrial requirements.

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GLOBE's databases

Weather data on GLOBE DATA ENTRY

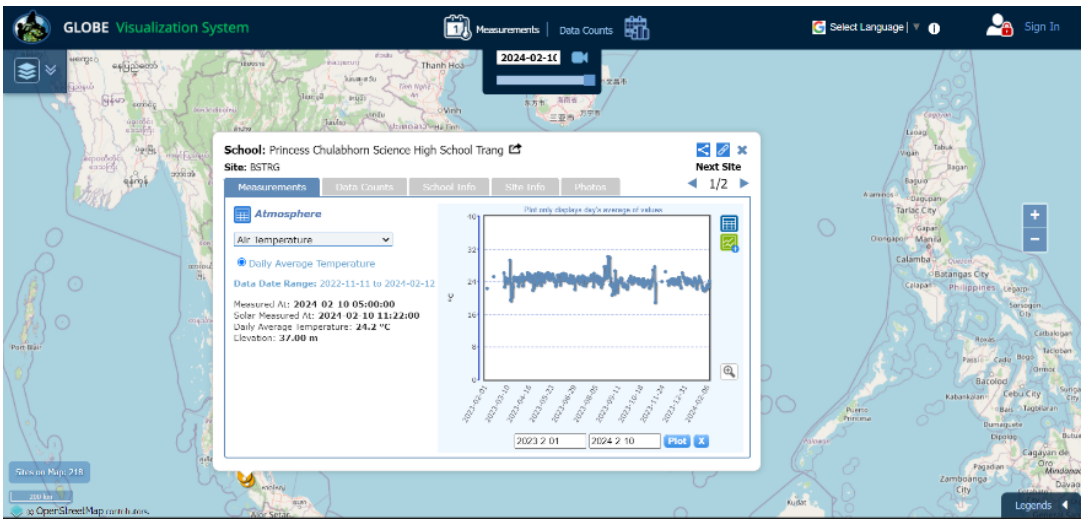

Figure 11: Shows the weather data at Bansuan Heritage Trang pepper on GLOBE DATA ENTRY

(Optional) Badge

I MAKE AN IMPACT

This research intends to assist farmers who are unable to produce red pepper, which is five times the value of black pepper, due to frequent weather fluctuations during harvest season, including low temperatures, high humidity, and a lot of rain. These factors will be affected to the moisture content of pepper seeds. Furthermore, farmers' sun-drying technique typically changes the color of red pepper, which should not be exposed to direct sunlight. As a result, the researchers design and develop the pepper hybrid drying machine that allows for controlling the temperature and humidity required for pepper drying and effective for 24 hours. Under climate change. This research will boost the income of small-scale farmers in the community while also increasing the value of Thai pepper exports.

I AM A STEM PROFESSIONAL

Our research covers STEM processes for innovation, such as scientific knowledge of heat distribution, heat transfer, and heat radiation from sunlight and heater, engineering knowledge of designing and innovating hybrid drying cabinet, technology knowledge of IoT system, which serve as real-time temperature and humidity reports via smartphone. Mathematical expertise is required to assess the various data sets under consideration using ANOVA.

I AM AN ENGINEER

This research uses engineering principles to design and develop a pepper drying cabinet. Begin by examining pepper drying process challenges under unfavorable weather conditions common to farmers, followed by research, writing, developing, testing, and improving innovation to achieve practical innovation.