# Automation Of Procedures For Experiments On Hybrid Crop Drying

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## ABSTRACT

Effective crop drying is a critical element in the drive for food security. Researchers from across the globe have sought to study various factors that lead to effective drying of agricultural products. They have also sought to optimize the time and energy spent on the drying of such products. In this enterprise, manual measurement and logging of parameters like temperature weight and wind speed have often presented some challenges. In this work, effort was made to develop a general procedure for automated measurement and logging of temperature, wind speed, relative humidity, mass, insolation and energy.

***Keywords***: *crop drying, measurement, automation, logging*

## 1.0 INTRODUCTION

Across the globe, post harvest losses significantly contribute to food insecurity [1]. Most post harvest losses may be as a result of improper handling of harvested agricultural products or outright spoilage of such products. Spoilage is often a result of internal agents (especially enzymatic activities) [2] and external agents (microbial) activities [3]. Enzymatic activities are natural to agricultural products. Their activities lead to ripening of fruits. Unfortunately, after ripening, further enzymatic activities result in deterioration of food quality. With respect to microbes, the presence of air and water inside harvested products enable them to continue with their activities, which result to putrefaction, fermentation and decay. These activities are further aided by high pH and temperature between 25 and 35OC [4].

Over the years, drying of agricultural products have been employed as a veritable means of quenching both enzymatic and microbial activities within agricultural products. This is achieved by subjecting the agricultural products to high temperature, which aided by appropriate airspeed, reduces the water activities of the products while deactivating the action of the microbes. In introducing high temperature for drying, there is always a trade off between using the heat to kill the microbes and using it to destroy the nutrients present in the agricultural product. There is also a trade off with respect to cost.

Accordingly, different types of dryers for agricultural products have been designed. When heating source is the primary consideration, popular classification include solar, electrical and hybrid dryers. When air circulation is the chief concern, popular brands include passive and active dryers. When the structure of the dryer is key, popular varieties include: tray, rotary, tunnel, trough, roller or drum, bin, fluidized bed, belt spray, vacuum , pneumatic, and freeze dryers. When considered in term of whether the heating and drying chambers are separated, common types include distributed and integral dryers. In all, the aim is to dry at the optimal conditions at the minimal cost.

In order to examine the performance of the different dryers, a number of parameters are usually measured. Commonly measured parameters include temperature, wind speed, relative humidity, mass of product, solar irradiance and energy consumption. In the measurement of these parameters it is common to use stand alone instruments like thermometer, multimeter, anemometer etc. This procedure involves considerable demand on time and energy on the part of the researcher. This is because the measurements would need to be done in 10, 15 or 30 minutes intervals. Again some of the measurements like measurement of mass would involve interruption of the process. This can introduce error.

In this work, an automated process of measurement using microprocessor, sensors and storage schemes is proposed as a replacement for manual measurement of parameters in drying experiments.

## 2.0 MATERIALS AND METHODS

### 2.1 Microcontrollers

A microcontroller is a small computer on a single integrated circuit which essentially contains a processor core, memory, and programmable input/output peripherals. The image in figure 1 captures the idea of integrating different components of a computer into a single chip to form the microcontroller.

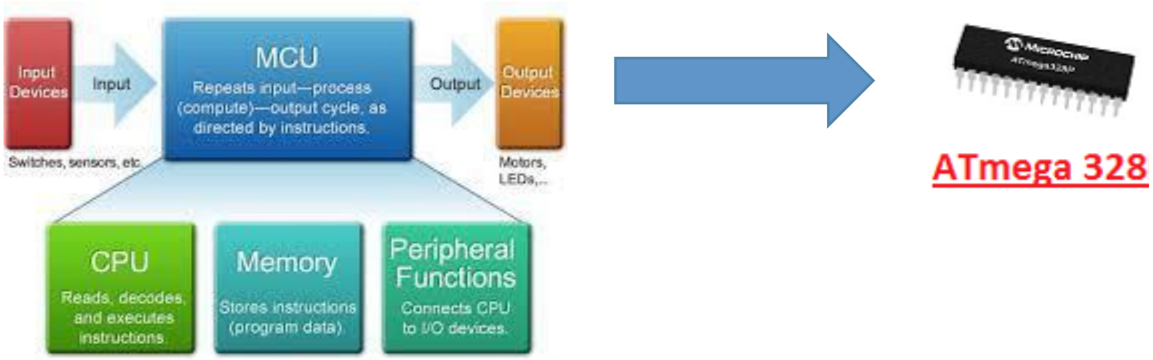

**Figure 1: Structure of microcontrollers**

The processor is the brain of the microcontroller. It coordinates all the operations necessary for the proper functioning of the microcontroller. Such operations may involve receiving data as input from the outside world, carrying out mathematical operations on data or controlling output devices.

As shown in figure 2, microcontrollers can be classified based on bus-width, memory location, family, instruction set or memory structure. In automation, any microcontroller can actually be used. The choice is often dependent on number of ports, cost and familiarity with a the programming language for a given microcontroller. In this work, esp 32 microcontroller manufactured by espressif is chosen. The choice is mainly because it has an integrated WiFi and Bluetooth capabilities. The number of analog and digital pins are also adequate for most measurement needs. More over the inter integrated I2C can easily be increased [5].

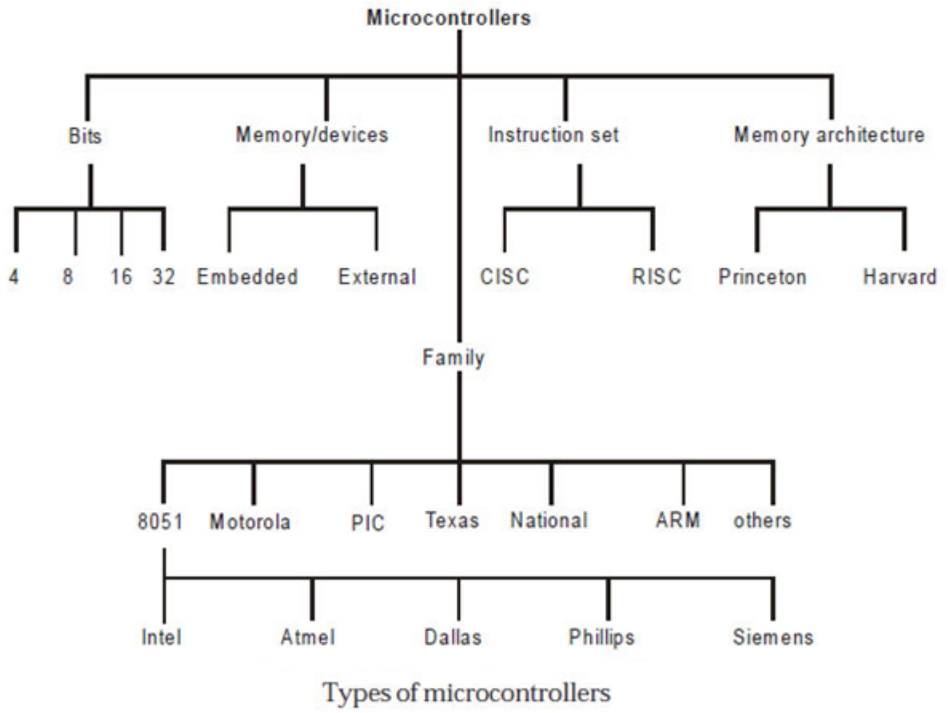

**Figure 2: Types of microcontrollers**

## 2.2 Temperature and humidity sensor

Common temperature sensor varieties include thermocouple, resistance temperature detectors (RTD), and thermistor. Each has its own operating principles, benefits, considerations, and drawbacks [6]. Similarly, there exists various types of humidity sensor. Based on the parameters used to measure humidity, these sensors are classified as Capacitive Humidity Sensor, Resistive Humidity Sensor, and Thermal Conductivity Humidity Sensor. In many cases, relative humidity sensors usually contain a humidity-sensing element along with a thermistor to measure temperature.

**Figure 3: Image of DHT22**

This is the case with DHT22, which is used in this work. Its picture is shown in figure 3. It can be described as a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air. It's fairly simple to use, but requires careful timing to grab data. Accordingly accurate measurements can be assured only after 2-3 second delay in between use [7]. This may not be an issue in the crop drying experiment, which usually takes place in hours. It is good for 0-100% humidity readings with 2-5% accuracy. The specified temperature range is for -40 to 80°C with accuracy of ±0.5°C.

## 2.3 Wind speed

An anemometer is a device used for measuring wind speed, and is a common weather station instrument. For the purposes of measurement automation, an anemometer with analog voltage output was chosen. The voltage range is from 0.4V (0 m/s wind) up to 2.0V (for 32.4m/s wind speed). The start wind speed is 0.2 m/s. It has a resolution of 0.1m/s and worst-case accuracy of 1m/s. Its diagram is shown in figure 4.

**Figure 4: The picture of wind speed sensor used.**

## 2.4 Load Sensor

A load cell is a sensor that converts a load or force acting on it into an electronic signal. Load cell can resistive load and capacitive. Resistive load cells work on the principle of piezo-resistivity. When a load/force/stress is applied to the sensor, it changes its resistance. This change in resistance leads to a change in output voltage when a input voltage is applied. Capacitive load cells work on the principle of change of capacitance, which is the ability of a system to hold a certain amount of charge when a voltage is applied to it. As shown in figure 5, load cells are usually used in combination with an instrumentation amplifier for better performance.

**Figure 5: A load cell with an instrumentation amplifier HX711.**

## 2.5 Irradiance measurement

For measurement of irradiance, two sensors TSL2591 and GUVA-S12SD were used. TSL2591, shown in Fig 6 is a very-high sensitivity light-to-voltage digital converter made by Adafruits. It consists of two photodiodes (one optimized to sense radiation in the visible region, the other radiation in the infra red region) with the conditioning circuit.

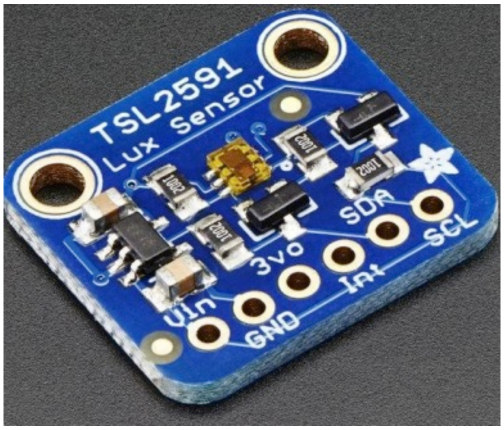

**Figure 6: TSL2591 lux sensor.**

GUVA-S12SD shown in figure 7 is photodiode module. It is optimized to respond to 240-370nm range of light (which covers UVB and most of UVA spectrum). Hence it is called UV sensor. The voltage output is directly proportional to the amount of UV present in the radiation.

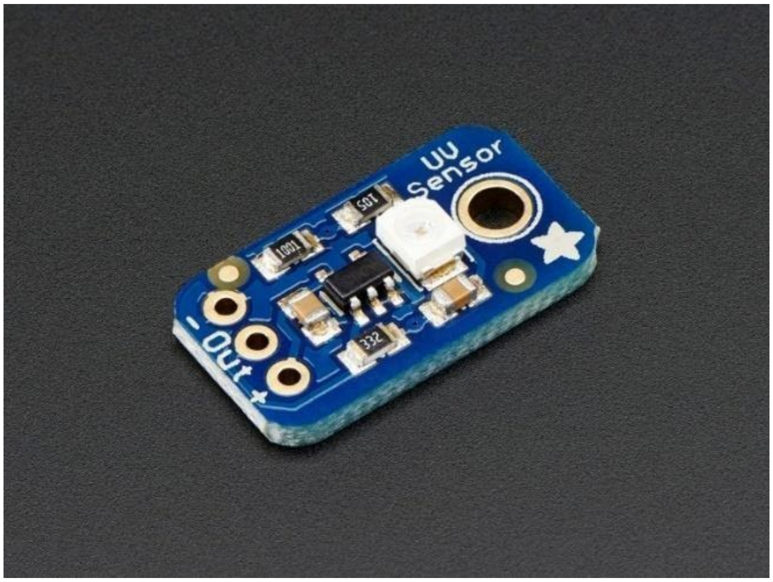

**Figure 7: Analog UV Light Sensor Breakout - GUVA-S12SD**

## 2.6 Measurement of Power

Instantaneous current was obtained by measuring the voltage drop across a precision shunt 100A/75mv(FL-2/0.5) shunt resistor and converting the same to current reading inside the microcontroller. To measure the voltage of the system, ZMPT101B single phase AC voltage sensor was used.

## 2.7 Data management

Finally in order to ensure integrity of data, the measured parameters were displayed in a 20X4 LCD, stored in an SD card and simultaneously sent to thingspeak® server.

## 3.0 DESIGN AND IMPLEMENTATION

At the integration level, the TSL2591 communicated with the microcontroller using I2C protocol. Using a library provided by the manufacturers, it was possible to accurately measure the infrared and visible component of the incident light. The individual sensor readings are then converted to W/m2. Communication with GUVA-S12SD was through analog pin. To ensure greater accuracy LM4040 was used for analog reference. A simple summation of the IR, visible light and UV gave the global irradiance. To validate the solarimeter, it was used to log irradiance reading for several days, the readings were compared with the reading recorded at the weather station at NCERD, UNN. A typical relationship curve is shown in Fig 8.

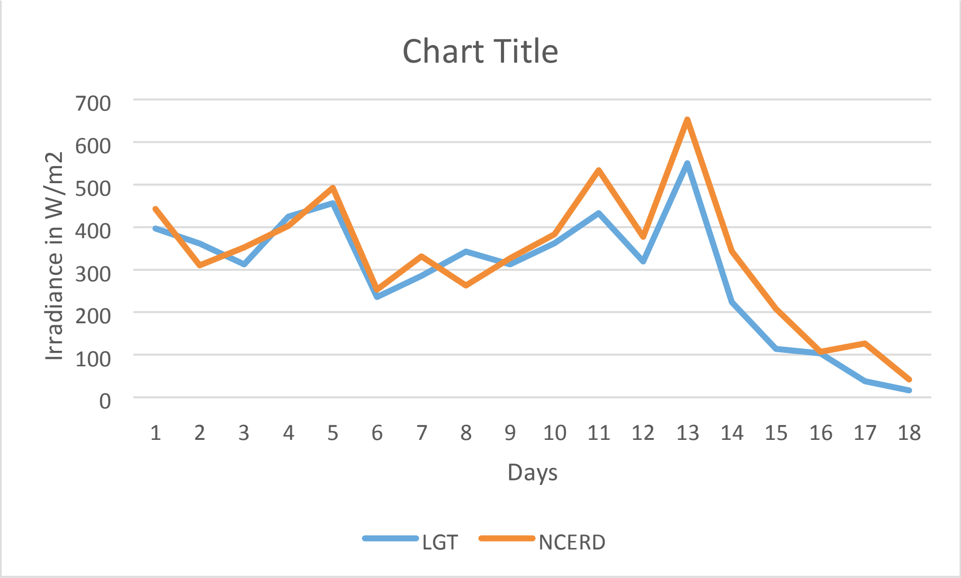

**Figure 8: Graph of solarimeter reading and weather station reading**

Regarding DHT 22, which communicates with the microcontroller using one wire protocol, also has a library produced by the manufacturers. As in the case of TSL2591, the library enables the module to give a calibration of temperature and relative humidity. AnalogRead command was also used to measure wind speed using a calibrating factor provided by the manufacturers.

To help in statistical analysis, a library called statistica was used to calculate the 30minutes, 60 minutes and daily averages of the measured parameters. The values are stored in in both SD card and thingspeak server. A diagram of the data logging system in operation at the test bed is shown in figure 9 while in figure 10 is shown the schematic diagram.

## 4.0 CONCLUSION

The system was designed, installed and tested in a real dryer. The parameters of interest were accurately measured and stored. For users who may like to replicate the system, it is to be noted that the load sensor need temperature calibration for effective operation. This is on account of the fact that the temperature within the chamber interferes with the strain seen by the aluminium sensor. In future work a more heat resistant sensor should be used. Outside the need for temperature compensation of the load sensor, it can thus be concluded that the system is efficient and can be deployed to ease the drudgery of manual measurement.

**Figure 9: Diagram of datalogger**

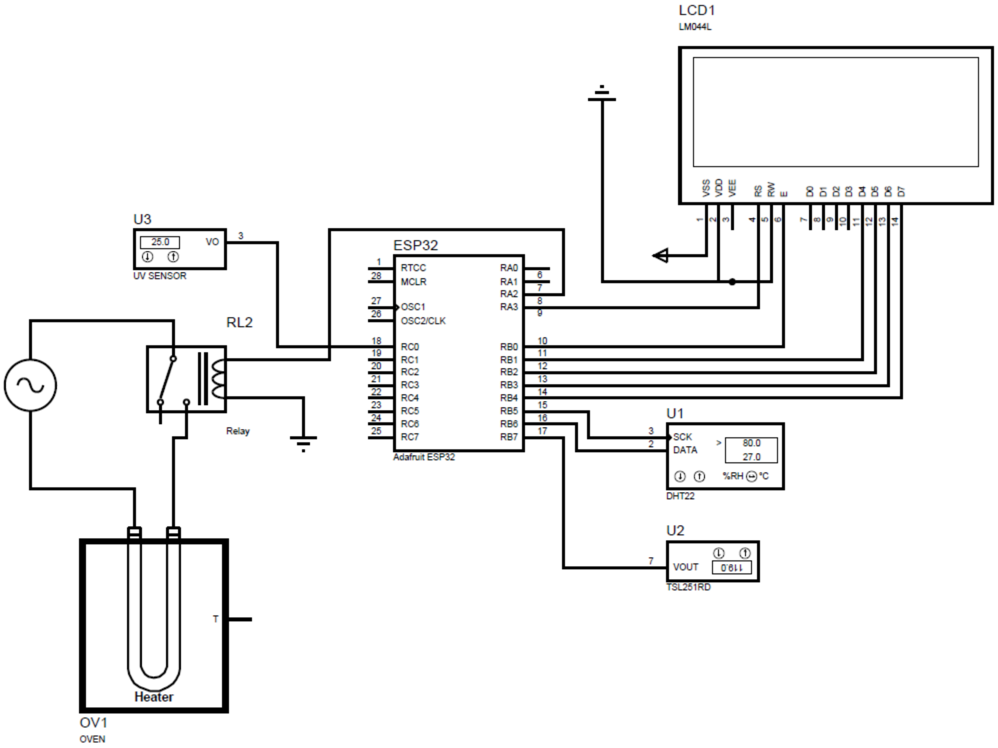

**Figure 10: A schematic diagram of the data logging system.**

## References

[1] Sawicka Barbara, "Post-harvest Losses of Agricultural Produce," in Zero Hunger, Springer International Publishing, 2019, pp. doi.org/10.1007/978-3-319-69626-3_40-1.

[2] Ma Meng, Qing-JieSun, Man Li, Ke-Xue Zhu, "Deterioration mechanisms of high-moisture wheat-based food – A review from physicochemical, structural, and molecular perspectives," Food Chemistry, vol. 318, p. 126495, 2020.

[3] Lianou A., Panagou E.Z.G. Nychas J.E., "Microbiological Spoilage of Foods and Beverages," in The Stability and Shelf Life of Food (Second Edition), doi.org/10.1016/B978-0-08-100435-7.00001-0, Woodhead Publishing Series in Food Science, Technology and Nutrition, 2016, pp. Pages 3-42.

[4] Olumide Adedokun Odeyemi,Oluwadara Oluwaseun Alegbeleye,Mariyana Strateva, Deyan Stratev, "Understanding spoilage microbial community and spoilagemechanisms in foods of animal origin," COMPREHENSIVE REVIEWS IN FOOD SCIENCE AND FOOD SAFETY, Vols. DOI: 10.1111/1541-4337.12526, p. 311–331, 2019.

[5] Expressiff, "ESP32 Series Datasheet," Espressif Systems, Shanghai, 2020.

[6] "https://www.ni.com/en-za/innovations/white-papers/06/overview-of-temperature-sensors.html," 2020. [Online].

[7] Lady Ada, "DHT11, DHT22 and AM2302 Sensors," Adafuit, USA, 2020.

[8] O. C. A. Peter Obasa, "Development of an Economical Automatic Temperature and Time Control Multipurpose Dryer," 2019.

[9] Robert Edward Chandler, "THE EFFECT OF TEMPERATURE AND WATER ACTIVITY ON MICROBIAL GROWTH RATE AND FOOD SPOILAGE.," University of Tasmania, Tasmania, 1988.

[10] Piyush Sabharwall, Vivek Utgikar & Fred Gunnerson, "Effect of Mass Flow Rate on the Convective Heat Transfer Coefficient: Analysis for Constant Velocity and Constant Area Case," Nuclear Technology, vol. 166, no. 2, pp. 197-200, 2009.

[11] RABIA ANUM, ABDUL GHAFOOR, ANJUM MUNIR, "STUDY OF THE DRYING BEHAVIOR AND PERFORMANCE EVALUATION OF GAS FIRED HYBRID SOLAR DRYER," Journal of Food Process Engineering I, vol. 40, p. e12351, 2017.

[12] K.S. Tonui, E.B.K. Mutai, D.A. Mutuli, D.O. Mbuge and K.V. Too, "Design and Evaluation of Solar Grain Dryer with a Back-up Heater," Research Journal of Applied Sciences, Engineering and Technology 7, vol. 7, no. 15, pp. :3036-3043, 2014.

[13] Matuam Balbine, Edoun Marcel, Kuitche Alexis, Zeghmati Belkacem, "Experimental Evaluation of the Thermal Performance of Dryer Airflow Configuration," International Journal of Energy Engineering , vol. 5, no. 4, pp. 80-86, 2015.