

# Digital Warehouse System for Vegetable Preservation

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## Abstract

Vegetable preservation is the process of storing vegetables for longer days by treating them in a right way. This enables the vegetables to not get waste from natural process. There are several technics followed in the agriculture field for preservation based on the nature of vegetables and fruits. Drying, pickling, canning, freezing, fermenting, salting and oil packing are some of the techniques that are widely employed for vegetable preservation. The proposed work aims to regulate the vegetable preservation process in the warehouse system by treating them with an automatic strategy. The strategy controls the temperature and humidity of the warehouse through customized fuzzy control algorithm included in the arduino microcontroller. The algorithm is designed to specify the kind of vegetable placed in the warehouse module for estimating the required temperature and humidity by its own. An experimental study is performed in the work to project the betterment of the work in terms of vegetable preserving days and efficiency over the manual and uncontrolled preservation methods.

**Keywords:** Automated warehouse, preservation methodologies, sensors in agriculture, wastage control, climate control

## 1. Introduction

Nature follows a standard time-table for vegetable and fruits growth. Based upon the climatic requirement of a human body the nature provides plenty of fruits and vegetables on-time. It makes every human to lead a healthy life throughout the year. However, the vitamins and other extracts of a fruits and vegetables are used for medicine, cosmetic and other range of applications. Hence it is must to ensure the availability of such natural raw products throughout the year [1]. The warehouse system is one of the oldest design used to preserve

the vegetables, fruits and other raw products. The different types of vegetable preserving methods are explored as follows.

### **1.1 Drying**

Drying is also referred as the process of dehydration that allows a vegetable or fruit to lose its water content to avoid the formation of bacteria over it. In general bacteria requires water to survive, therefore the drying process allows the vegetable to not produce any bacteria over its surface. Due to the removal of water content from a vegetable or fruit, it may look smaller in size and can lose its weight. This can be rectified by adding water or keeping the vegetables over a water container for few minutes to regain its nature and original position. The basic drying process requires a dehydrator system or oven and that requires a human support to load the vegetables into the product. It is also must to specify the right temperature and time for the fruit dehydration process into the oven system. In present days the solar dehydrators are preferred by the industrial experts for the drying application because of its nature on green energy utilization. The dehydrators are comparatively efficient over the ovens as they require less time for its operation. In some applications the ovens are employed as a preheater for the dehydration and drying process [2].

### **1.2 Canning**

Canning is the process of storing the vegetables or fruits in a glass or tin containers and make to be heated with a specific temperature for removing the microorganism presence. It also reduces the presence of enzymes and the continuous process of heating and cooling makes steam pressure to produce a vacuum seal inside the container. The validity of the canned foods are large than the regular foods that allows the food to be safe for several months [3].

### **1.3 Salting/Fermenting**

Salting is also referred to the process of dehydration where the salt is used to observe the moisture presence over the fruits or vegetables. The hypertonic nature of the sault makes a discomfort to the bacteria to survive on the vegetables. However, the salting process allows the microorganisms to stay at the bay of vegetables to make them to not lose its natural flavors. In many cases the salting process is done by the help of brine. Brine is also referred as saltwater mixture where the vegetables are placed over the tank of water and the salts are poured inside the water to get deposited over the fruits and vegetables. The salt deposit over

the vegetables indicates a saturation point and now the vegetables are kept inside a refrigerator for seven days and it can be kept after that in a dry place for longer days [4].

#### **1.4 Pickling**

Pickling utilizes the vinegar for preservation. The inhospitable nature of vinegar makes the bacteria to survive over the vegetables for few minutes. Therefore the vegetables and fruits that are employed pickling process can be preserved for at least few years. However, the process of pickling changes the natural flavor of the vegetable to an extreme level. The pickling process is done by adding salt and sugar with the vinegar solution to make the vegetable or fruit to be merged inside it on a jar [5].

#### **1.5 Freezing**

Freezing is one of the easiest way for preserving the fruits and vegetables. It allows the summer fruits to be preserved till winter season. Though, the process of freezing may damage the surfaces of softer fruits. It may change the color and texture of the fruits in some cases. Therefore the process of freezing is widely employed for the harder vegetables. Similarly the process of freezing won't kill the bacteria same as like of the other methods in an efficient way until the vegetable gets defrosted. The ascorbic acid is used in few cases for preserving the color of the vegetables and fruits on freezing process [6].

#### **1.6 Oil Packing**

Vegetable oils are used in some cases for vegetable preservation. It make the bacteria to not develop in the oily container but it modifies the nature of the vegetables. Therefore these methods are employed for the harder vegetables. The addition of vinegar to the vegetable oil can provide a no air condition and that allows the vegetables to be preserved for longer days than the usual [7].

### **2. Motivation for the Work**

It has been observed that most of the methodologies followed for vegetable and fruit preservation requires an optimum temperature for its operation and it is observed that small quantity of vegetables can be preserved with home refrigerator and home oven system. The demand for warehouse system comes when large quantity of vegetables and fruits are required to be preserved. Therefore the need for controlling the temperature of the warehouse

area is also demands a quit better automated control system. The following section explores the attainments of the various systems on warehouse management application.

### 3. Literature Study

An IoT based warehouse control system was developed to send the climatic changes inside the warehouse to the farmers on abnormal condition to take specific actions [8]. The work is also further extended to take decision by its own using the decision tree supervised algorithm. An IoT gadget was developed to present the status of warehouse by time to time to avoid fruit and vegetable wastage on post-harvest condition. The system was structured to provide the temperature and other parameters inside the warehouse on regular time interval [9]. The IoT systems were also employed in the agriculture field for effective yield making process where the system is equipped with gas sensor and temperature sensor to monitor the state of the growth of the vegetables. The algorithm included in the microcontroller is designed to make an alert signal to user on observing abnormality [10].

A K-mean clustering based technique was developed to control the humidity and temperature of a warehouse system. The warehouse is monitored with several sensors and the informations are gathered to the microcontroller system to regulate the control process. The data that are received to the microcontroller controller is taken into account by the K-mean clustering algorithm for processing the control operations. The system is also connected with an IoT dashboard for monitoring the status of the system [11]. The warehouse system can also be used in various other applications like pharmacy product preservation where the same temperature and humidity are maintained with an automated process. A fuzzy logic-based control system was proposed for such application and found a betterment of longer day preservation of medical products [12]. An edge computing based warehouse monitoring system was designed to provide a real-time information about the climate inside the warehouse. The usage of edge computing makes the system to consume low power and low latency operated system [13].

The food preserving warehouse systems are also equipped with robotic approaches for making the system to be monitored in a continuous and efficient manner. The robotic system were widely helpful on pandemic situations in handling the items stored in the warehouses [14]. A non-linear solution algorithm were proposed to operate the carbon emissions presence from a warehouse system. The warehouse systems are affected with carbon emissions in many cases where the warehouses are operated with an IC engine for sorting or transporting

the product. Therefore a secured system is incorporated in warehouse and greenhouse kind of applications to monitor the carbon emissions [15]. The warehouses are usually made with an automatic operatic system that improves the hygiene of the stored products. The proper sanitation process on the warehouse system make the products to maintain its quality to certain extent [16].

It has been observed that the warehouse preservation systems are considerably high in operating cost. Therefore a solar based warehouse system was structured for plant-based food presentation. The solar warehouse systems are effective in terms of cost and carbon emissions [17]. The IoT based methodologies are also incorporated to the food and grain warehouses where the collected information are shared to the farmer through email notifications by the help of wifi enabled system [18]. A self-tuning PID technology was incorporated with PLC controller for preserving fruits and vegetables in an efficient way. The system was designed to preserve the vegetables like ginger and garlic. An experimental work was performed to find the efficiency of the system in terms of precision towards its operation [19].

The literature section indicated that the warehouse systems that the developed so far are majorly structured with the following methodologies.

- IoT
- Edge
- PLC
- Robotic

The common thing that is observed on all these methodologies are data collection. All these methods are equipped with a standard sensor modules for observing the temperature, humidity and gas explosion inside the warehouse systems. The only difference in all such systems are their processing method. Most of the systems are designed to provide alert signal to the farmer on critical conditions.

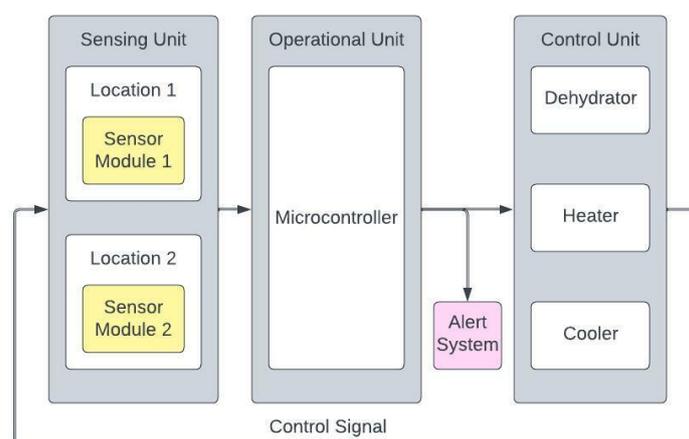
#### **4. Proposed Work**

The proposed work aims to develop a warehouse control system for onion, potato and tomato. The work makes a complete control system that includes a low cost operational algorithm developed based on customized fuzzy control. The algorithm takes decision by measuring the temperature, humidity, Carbon dioxide, smoke, vibration and motion through different sensors connected at various positions on the warehouse system. The warehouse is

structured to preserve onion, potato and tomato. Therefore the operational condition of the warehouse gets differ based upon its requirement. Figure 1 indicates the architectural overview of the proposed system.

The system is equipped with three major units called sensing unit, operational unit and control unit. The sensing unit contains 'n' number of sensing modules that has different kind of sensors to observe various factor controlling factors from its surrounding. The collected signals are forwarded towards the operational unit to take decisions for controlling the dehydrator, heater and cooler modules available in the control unit. Based upon the control signals received from the control unit the vegetables that are placed at various locations of the warehouse are going to be preserved in an efficient way. The work also enable an alert signal to the farmer when the system could not able to control the temperature and other parameters. The novel contribution of the work is as follows.

- The work decides the control signal on its own based on the vegetable included in the warehouse.
- The type of vegetable included in the warehouse can be included specified to the microcontroller with a customized signal.
- The system enables an alert system when the system faces any deviation on its operational process.



**Figure 1.** Architecture of the proposed system

The control signals are decided based upon the signals observed from the sensors and a threshold variation up to 3% is allowed in the system before enabling an alert signal. An experimental study was performed in the work with a prototype to measure the efficiency and preservation time of the vegetable. The preservation time of the vegetable is calculated based on the temperature maintained in the prototype.

## 5. Experimental Work and Discussion

The experimental work was performed with a 12 hours experiment in a developed prototype. The temperature of the prototype is varied with the external control unit and measured the performance of the system every 30 minutes. Table 1 indicates the temperature deviations in terms of precision for onion, potato and tomato and table 2 represents the comparative analysis of the proposed system with uncontrolled automated system and manual system in terms of preserving time.

**Table 1.** Performance of the proposed system

Parameters	Mean Precision		
	Onion Temp. 25-30°C Hum. 65-70%	Potato Temp. 6-8°C Hum. 80-90%	Tomato Temp. 22-25°C Hum. 65-75%
Temperature	±0.5	±0.7	±1.2
Humidity	±0.2	±0.2	±0.25

**Table 2.** Comparative analysis of the proposed model with the existing methods

Vegetable	Preserving Days			
	Maximum Days (Theoretically)	Proposed System	Uncontrolled System [10]	Manual Method
Onion	243-273	201	120	75
Potato	209-216	154	82	59
Tomato	180	111	69	43

Table 1 represents the mean precision of the proposed system by analyzing the average value taken on every 30 minutes in the developed prototype. The experimental outcome indicates a maximum precision of ±0.5°C on temperature for the onion and ±0.2% of humidity for both onion and potato. The performance of the work is also compared with the existing uncontrolled system [3] where the system alerts the farmer on temperature and humidity variation and the farmer needs to take action for the temperature management system. The manual control system works similar to the uncontrolled system where the farmer needs to measure the temperature of the warehouse at regular interval of time. Table 2 estimates the days the vegetables can be preserved based on the mean precision observation calculated in the system. It also indicates that the proposed work performs better over the uncontrolled and manual system.

## 6. Conclusion

Vegetable preservation is one of the clever idea done by the humans to store for supplying the vegetables throughout the year. The proposed system designed a low cost and low computational system for preserving the vegetables in an efficient manner in the warehouse system. The work is incorporated with an arduino controller along with temperature and humidity sensors for measuring the preserving condition of the vegetables. The system is also equipped with a heater, cooler and dehydrator setup for the controlling phase. The experimental work was conducted to prove the efficiency of the system over the existing methods and the analysis proves it's a better solution among the other methods. The work is also equipped with an alert system, though it requires more optimum analytic algorithm for real-time implementation. The performance of the proposed system may get deviation on real-time setup where the temperatures are random in nature. Similarly the work will also be improved in future by adding an efficient algorithm for the analysis along with a system to observe the kind of faults in the system as a notification to the user because there is a chance for vegetables to get damaged in uncontrolled conditions during a fault on the preservation system.

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