SMART ONION STORAGE WITH ENERGY HARVESTING USING IOT

AJAY VEERABAGHU.T

*Department Of Information Technology Velammal College Of Engineering And Technology*

*Madurai, India*

[ajayveerabaghu46@gmail.com](mailto:ajayveerabaghu46@gmail.com)

SAKTHIVEL.T

*Department Of Information Technology Velammal College Of Engineering And Technology*

*Madurai, India*

[sakthivelthirumaran@gmail.com](mailto:sakthivelthirumaran@gmail.com)

KAMALESH.S

*Faculty*

*Department Of Information Technology Velammal College Of Engineering And Technology*

*Madurai, India*

[skl@vcet.ac.in](mailto:skl@vcet.ac.in)

***Abstract*—*To extend shelf life of onion with low cost smart storage with our proposed Iot architecture. We use freight containers as our cold storage unit. Considering the large size and low price of it.***

***Keywords—Smart storage, freight containers, cold storage.***

1. **INTRODUCTION**

The objective of the Consumer Affairs Department of the Ministry of Consumer Affairs is to provide quality agricultural products and produce to a wide range of consumers at affordable prices. One of the most important raw materials is onions, the prices of which fluctuate greatly for several reasons. In addition to flavor, onions provide important nutrients and health-promoting phytochemicals. It contains B vitamins and vitamin C, as well as traces of iron and calcium. As a culinary ingredient, it adds aroma and flavor to various foods and is also used as a salad dressing. Thus, the demand for onions is constantly increasing all over the world. India's onion production is around 26.91 million tonnes and the planted area is 16.28 million hectares (2020-21). On an average, India consumes about 1 million tonnes of onion per month and to meet this demand, the crop is grown in three seasons – Kharif (planted from July to August and harvested from October to December); late Kharif (10 and Rabi (planted) from December to January and harvested from March to May) [1]. In general, two temperature and humidity levels are used to store onions,

i. e. 25 to 30°C and 65 to 70 percent relative humidity, as well as 0 to 2°C. Onion is kept at room temperature in tropical regions. structures of various types. Due to improper pre-and, storage losses in tropical regions are very high (30–40%). combined with unfavorable storage conditions and post-harvest management [2]. Thirty different onion genotypes were subjected to an experiment to examine how they stored over the course of four months in ambient conditions. The study's findings showed that after four months of storage, Bhima Shakti sprouting was at its lowest percentage (7.68%) and N-53 sprouting was at its highest percentage (15.10). Bhima Shakti had the lowest percentage of rotting (7.34%), and N-53 had the highest percentage of rotting (14.78%).After 4 months of storage, the cultivar Bhima Shakti (16.05%) experienced the least weight loss, whereas Poona Nasangi (28.63%) experienced the most weight loss [19]. Onions are primarily grown in West Bengal (India) during the Rabi season. A novel region for growing onions is West Bengal's Coastal Saline Zone. After 180 days of storage, the average physiological weight loss, rotting, sprouting, and total loss were recorded as 33.6, 24.8, 1.3, and 59.7%, respectively. After six months of storage, onion cultivars experienced complete losses ranging from 20.0 to 99.6% [20]. Thus,

the Rabi onion crop is the backbone of India. As rangda onions often yield inferior-quality bulbs, they demonstrated low storage quality. Eight potential dark red onion genotypes and three control cultivars underwent storage testing for three months. Only marketable bulbs that had received post-harvest treatment were used for the storage research. With no sprouting or rotting losses, the genotypes Sangamner-3 and Sangamner-1 exhibited much lower total losses (2.17 and 3.03%, respectively). After the third month of storage, a 15.98% mean total loss was observed, which included losses from rotting, sprouting, and 13.18% physiological weight loss [21]. The storage period had high RH above 75% during the wet season. There is no interaction impact between these two parameters, however both the temperature and RH effects are significant at = 0.05 on the percentage losses. Under two temperatures and three RH conditions, the difference in the weight loss caused by moisture loss was significant at = 0.05. The optimal storage conditions, per the findings, were found to be 75% RH and 25 o C temperature [16]. Generally, onion prices are lower during these months due to increased supply. It is very important for India to successfully store rabies onions to ensure that the markets are supplied during the lean months. In addition, scientific management of onion cultivation in all three seasons is also essential to increase conventional supply. If the Rabi crop area is reduced due to insufficient or limited irrigation water, or if crops are damaged by hail and pre- monsoon rains, yields will decline, leading to higher prices. About Rs 11 lakh is lost every year due to improper storage system. It would make sense to invest large sums in developing technological solutions to the problems plaguing the onion industry, and the returns would be attractive. The traditional method of cooking onion skins, while saving money, has high storage losses and huts are not economically viable.

Recent technological advances (e.g. design, solar/plasma/radiation energy, nanotechnology, Internet of Things including artificial intelligence/machine learning) also provide opportunities to improve onion storage and supply chains even in rural India. infrastructure and value added services. Design innovation permeates all sectors, including efficient storage of onions for agricultural, rural and urban markets. Various advances in process and product development will ensure better returns for farmers and more competitive prices for consumers. More importantly, it will help address current and imminent challenges.

1. **STATUS OF ESTABLISHED ONION STORAGE STRUCTURES AND CHALLENGES**

Either great onion storage facilities or off-season growing can ensure a consistent supply of onions throughout the year. There are a few things to keep in mind when storing onions for a longer time. These include managing storage chemicals and irradiation treatment for reducing storage losses, managing onion storage diseases, choosing cultivars that are suitable for storage, the impact of crop management practises on storage quality (nutrition and irrigation), and the impact of an integrated approach for reducing storage losses [15].The four-month storage life of 20 onion cultivars was investigated in ambient settings. Bhima Kiran showed the least overall weight loss after three months of storage (7.73%), whereas Agrifound dark red showed the most reduction in weight (28.50%). While cultivar Arka Bindu (12.80%) experienced the least weight loss overall throughout the course of four months of storage [17]. It was shown that two onion cultivars may be stored in the Western Mountain region of Libya without refrigeration. A typical underground bunker-like dwelling (UGH) and a shaded area were investigated as storage conditions. UGH demonstrated good storage potential; its temperature and relative humidity were consistent over the storage period, cooler than the outside during warm months, and less humid during cold months; providing generally ideal conditions for onions to be stored for a brief period of time. It was discovered that the Red Amposta cultivar was vulnerable to sprouting. Its storage time was estimated to be 100 days, and its overall losses were 27% and 21% for shade and UGH circumstances, respectively. On the other hand, Yellow Spanish was stored for 150 days, with cumulative losses of 21% and 16% mass in shade and UGH, respectively [18]. The NHRDF created three different types of onion storage structures, and the domestic onion storage structures are located in Kalwan. The cost of building this structure, i.e., the traditional onion storage structure, the Dindigul onion storage structure, and the improved low cost onion storage structure designed by NHRDF, is $1.50 per square foot. There are some losses encountered in storage, including weight losses, rotting losses, and sprouting losses.When compared to household onion storage structures, this losses were shown to be higher in the storage structure built by NHRDF. (Kalwan) [13]. The storage cabinet was made of three sections of divided wood, and the sides were lined with fine wire mesh. The onion bulbs were sized, classified as small, medium, and large. According to experimental results, the size of the onion affects how quickly it deteriorates [14]. A new storage structure was created using materials that were readily available in the area, tested for nine weeks, and found to be capable of holding onions in a humid tropical environment.The results of the test of correlation analysis showed a considerable disparity between the interior and external values of temperature and relative humidity. By lowering the ambient temperature and relative humidity and extending the product's shelf life, it can be said that the building has worked satisfactorily [12].

1. *Naturally ventilated structures (Kandha Chawl):*

Kandha Chawl is a naturally ventilated structure, a scientific onion shed to reduce storage losses. In India, onions are mostly stored in such structures without temperature and

relative humidity control. Farmers build different types of Kandha Chawl according to the required capacity.

*Low Cost Thatched Roof Bamboo Storage Structures*: This type of storage structure usually consists of a bamboo frame with a roof made of sugarcane leaves and is recommended for storing onion "farms". This is a single row storage structure that can be made with a capacity of 5 to 10 tons. The structure is made with bamboo rafters. Whole solid bamboo is used for columns and roof beams. Half-split bamboo is used for the floor, while the side walls are made of split bamboo (1/6). The entire bamboo column is five feet apart. Angles provide support for all columns. The lower ventilation is reinforced with bricks at the bottom of all the iron corner posts. Roofs are usually made of sugar cane leaves, but a similar type of grass can also be used. Gunny fabric lining comes to check the rainwater leakage. This type of structure must be made north. This type of storage structure is cheap and easy to build, but onion losses are up to 40-42% during four months of storage. The strength of the structure is low due to the use of organic materials/bamboo. Temperature and humidity cannot be controlled due to the natural ventilation mechanism [1].

Challenges :

* + Durability and strength of storage structure
  + 40-42% losses
  + Low storage duration (as onions can be efficiently stored upto 3-4 months)
  + Abiotic factors

1. *Bottom and side ventilated storage structure:*

It provides an airy floor of wooden posts, a central ventilation duct and an extended roof. The construction frame is made with galvanized iron channels. The floor and side walls are made of 2.5 cm thick wooden dowels with 2.5 cm gaps between the gnomes. The roof is made of asbestos sheets. The roof is extended up to 1 meter to avoid rain splashes. This type of construction provides ventilation from the bottom and sides. These current dominant structures may vary in their capacity and cost to meet the demands of all income groups of farmers/traders. Although these naturally ventilated storage structures are well used, significant losses can still occur due to the inability to control temperature, relative humidity and air flow, which are essential for successful onion storage with minimal losses. The construction of the 50 MT double row modernization of the bottom and side ventilated warehouse structure will cost approx. Rs. Seven hundred thousand. Most Indian farmers store their onions in this naturally ventilated storage structure, but this structure is not suitable for extreme heat and high relative humidity/high temperature and low relative humidity or low temperature and high relative humidity areas [1].

Challenges:

* + Reduction in cost
  + Durability and strength of storage structure
  + Reduction in storage losses (Current losses: ~ 46% in 4 months)
  + Abiotic factors

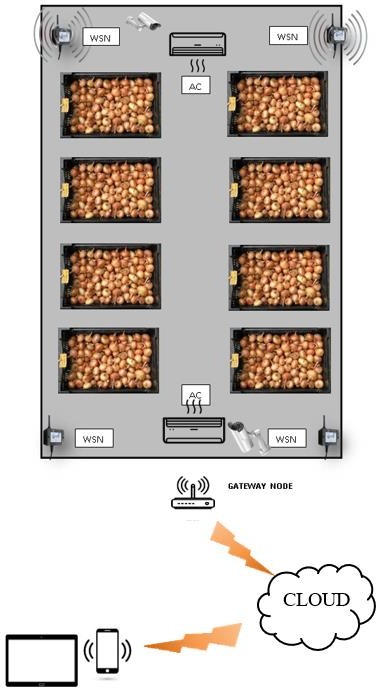
1. *Controlled onion storage structures:*

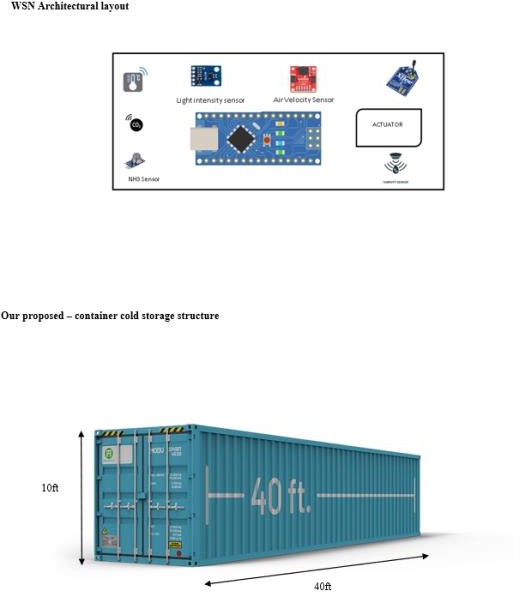
Although some countries use refrigeration systems for onions, India has rarely adopted such a system due to poor economic conditions and lack of cold chain facilities required to maintain quality in the country's high ambient temperature. Storage of onions under ventilated conditions is very satisfactory when the temperature is maintained between 25oC and 30oC and the relative humidity varies between 65- 70%. A controlled onion storage structure, where onions are stored at 0-5°C and 60-65% relative humidity, has much lower losses than a ventilated storage structure. Construction costs (approx. 20-2.5 million/20 tons) and running costs (i.e. Rs.0.60-0.65/kg/month) are very high due to high energy requirement in the storage to maintain the temperature between 0-5°C. The second problem is condensation, which requires a lot of effort and time. Onions begin to sprout as soon as they are taken out of the freezer [1].

Challenges:

* + Proper circulation of cold air inside the structure
  + High capital investment and operating cost
  + High energy requirement and power failure affect the storage life of onions.
  + Environmental sustainability issue.
  + Required highly skilled manpower
  + Durability and strength of storage structure

1. **PROPOSED ARCHITECTURE:**





# WORKING PROCEDURE

* First of all, we chose a shipping container for our cold storage, which can hold around 40 tons of onions and which can be bought or rented at a cheaper price. Given its large size and cheap price, we considered it a better choice.
* After the bulbs are stored inside the container, a temperature and humidity sensor signals the air conditioner to cool the containers to the required temperature and maintain the ambient humidity.
* The light intensity sensor detects if the light inside the container increases.
* C02 and NH3 sensors alert us to the concentration of chemicals emitted by the bulb.
* We also use wind speed sensors to maintain the air speed in the container within the permissible limit.
* A pressure sensor ensures that the pressure around the bulb is monitored.
* Since all these sensors need to be connected to a common microprocessor, we used Arduino, which is a cost-effective and efficient chip, comparing other alternatives.
* Xbees. Gateway nodes help us transfer the collected information from all these sensors to the cloud, where the data is processed and displayed using free, open source data visualization software.
* All these units are powered by solar panels mounted on the outer surface of the container.
* Based on this collected data, we can interpret the general trends and condition of these onions and then improve the system to be an effective and comprehensive solution for extending the shelf life of onions.
* As we are implementing this project in a "cargo container" - appropriate changes will be made to piping components to ensure efficient storage

# COMPONENTS

1. **Arduino Nano:**

The Arduino Nano is a small, complete, breadboard-friendly circuit board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality as the Arduino Duemilanove, but in a different package. It only has a DC plug and a Mini-B USB cable can be used instead of the standard cable.

# Temperature sensor and Humidity sensor:

A temperature sensor is an electronic device that measures ambient temperature and converts input data into electronic data to detect, monitor, or signal changes in temperature. There are many different types of temperature sensors. Some temperature sensors require direct contact with the physical object being monitored (contact temperature sensors), while others measure the temperature of the object indirectly (non- contact temperature sensor). A humidity sensor is an electronic device that measures humidity in the environment and converts the obtained result into a corresponding electrical signal. Humidity sensors vary greatly in size and functionality; some humidity sensors can be found in handheld devices such as smartphones, while others are integrated into larger embedded systems such as air quality monitoring systems. Humidity sensors are commonly used in meteorology, medical, automotive, HVAC, and manufacturing industries.

# A pressure sensor:

A pressure sensor is an electronic device that detects, regulates, or monitors pressure and converts recorded physical data into an electrical signal. Pressure is defined as the force (of a liquid or gas) acting on a unit of "area" (P=F/A), and the traditional unit of pressure is the Pascal (that is, one newton per square meter). Pressure sensors typically use piezoelectric technology, as a piezoelectric element releases an electrical charge proportional to the pressure it is subjected to (caused by pressure).

# Carbon dioxide sensor:

A carbon dioxide sensor or CO2 sensor is an instrument used to measure carbon dioxide gas. The most common principles of CO2 sensors are infrared gas sensors (NDIR) and chemical gas sensors. Carbon dioxide measurement is important for monitoring indoor air quality, lung function in the form of capnography devices, and many industrial processes. This is the first Arduino compatible CO2 sensor. The output voltage of the module decreases as the CO2 concentration increases. A built-in potentiometer is designed to set the voltage threshold. As long as the CO2 concentration is high enough (voltage below the threshold), the digital signal (ON/OFF) is released. The signal output circuit for the heat sensor MG- 811 is very sensitive to CO2, less sensitive to alcohol and CO. CO2 output voltage increases. Suitable for greenhouse and medical projects. Sends an analog signal that decreases with increasing CO2 concentration.

# Ammonia gas sensor:

The MQ137 sensor belongs to the MQ series and detects various gases in the air. The MQ137 is an ammonia gas sensor that detects the presence of ammonia gas. As the

concentration of N gas in the air increases, the conductivity of the sensor tends to become higher. Using an electrical circuit, you can convert this change in conductivity into an output value that indicates the concentration of the gas. In addition to ammonia, it can also detect organic amines.

CO2 concentration increases.

# Light intensity sensor:

The BH1750 module is a digital ambient light sensor with IIC I2C communication. Suitable for arduino light detection. It is a light intensity sensor breakout board with a built-in 16-bit AD converter, which can directly output digital signals without complex calculations. This is a more accurate and easier to use version of a simple LDR that outputs only the voltages that need to be calculated to get meaningful data. The BH1750 Light Sensor strength can be measured directly at the luxury table for free. It is a photodetector that is used to detect the amount of ambient light and dim the device's screen accordingly to match it. Thus, the screen is not too bright when the user's pupils are adapted to see in a dark room, or too dim when the device is used outdoors during the day. The BH1750 is a 16-bit ambient light sensor that communicates via the I2C protocol. It outputs photometric measurements in lux (the SI unit of illumination). It can measure a minimum of 1 lux and a maximum of 65,535 lux. Sensors can come in different breakout board formats. Look down. Both images represent the BH1750 sensor. The BH1750 provides 16-bit light measurements in lux, the SI unit for measuring light, allowing easy comparison with other values such as references and measured values from other sensors. The BH1750 is capable of measuring from 0 to 65 K+ lux. With a few calibrations and advanced measurement time adjustments, it can even be convinced to measure up to 100,000 lux!

# XBee modules :

XBee modules were created by Digi International primarily as radio transceivers and receivers. It is a network communication protocol based on the IEEE 802.15.4 ZigBee standard. XBee supports point-to-point and point-to- multipoint wireless network communications at 250 kbit/s.

# Nicla Vision:

Nicla Vision combines a powerful STM32H747AII6 dual ARM® Cortex® M7/M4 IC processor and a TinyML- enabled 2MP color camera with a smart 6-axis motion sensor, integrated microphone and distance sensor. You can easily incorporate it into any project as it is designed to be compatible with all Arduino Portenta and MKR products, fully integrated with OpenMV, supports MicroPython and also offers WiFi and Bluetooth® Low Energy connectivity. It is very compact - 22.86 x 22.86 mm form factor

- It can be physically adapted to most scenarios, requires very little power and can be battery operated for independent applications.

# Gateway node:

Powered by RAKwireless™, the Arduino Pro WisGate Edge Lite 2 provides secure and reliable connectivity for a wide range of professional applications, suitable for medium to wide area coverage in industrial environments. Its deep indoor coverage makes it ideal for multi-storey buildings

such as apartment buildings, multi-storey car parks and factories. An IoT gateway is a centralized hub that connects IoT devices and sensors for cloud computing and computing. Today's IoT gateways typically provide two-way data flow between the cloud and IoT devices. It allows you to upload IoT sensor data to process and send commands from cloud applications to IoT devices.

The WisGate Edge Lite 2 Gateway is a high-reliability device that allows you to set up home and small and medium-sized industrial indoor LoRaWAN® applications with high performance efficiency. It supports 8 LoRa channels, Ethernet multi-backhaul, Wi-Fi and cellular connectivity. The gateway provides OpenWRT, which allows you to develop custom applications.

# Wireless sensor network(WSN):

IoT (Internet of Things) wireless sensor network (WSN) refers to a spatially distributed group of dedicated sensors that monitor and record physical conditions in the environment and centrally deliver this data to the Internet via a wireless network. Place. WSNs measure environmental conditions such as temperature, sound, pollution levels, humidity, wind speed and direction, pressure, and more.

# ECONOMICS OF COLD STORAGE:

Below table shows the economics of existing cold storage. Here we compare cost of onion storage per ton and cost of onion storage per 2000 ton. From the below table we infer the current economics of existing storage

# ECONOMIC OF COLD STORAGE BASED ON OUR PROPOSED CONTAINER STORAGE:

Below table shows the economics of our proposed container storage . Here we compare cost of onion storage per ton and cost of onion storage per 30 ton because our container capcity is 30 ton. From the below table we infer the economics of our proposed storage.

|  |  |  |
| --- | --- | --- |
| **Particular** | **Cost of onion storage/ton** | **Cost of onion storage/30 ton** |
| Total storage capacity(tones) | 1 | 30 |
| Value of onion @Rs 2000/ton | 2000 | 60000 |
| Cost of storage of onion(rs/year)/repay ment | 722 | 21666 |
| Cost of sorting@ Rs 70/ton | 70 | 2100 |
| Cost of electricity charges | - | - |
| Maintenance | 266 | 8000 |
| Cost of irradiation | 15 | 450 |
| **A)Total expenditure(Rs)** | 3004 | 92,246 |
| Total salable good bulbs(ton) | 0.95 | 28.5 |
| Total salable sprouted and black mold bulbs(ton) | 0 | 0 |
| **B)Total Returns(Rs)** | | |
| Onion@6000/t | 5700 | 171000 |
| Sprouted and black mold affected bulbs@Rs 1000/ton | 0 | 0 |
| Total Value(Rs) | 5700 | 171000 |
| Net Profit(Rs)(B-A) | 2696 | 78754 |
| Net Profit(Rs/t) | 89.99 | 2625 |

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No.** | **Particular** | **Cost of onion storage/to n** | **Cost of onion storage/ 2000 ton** |
| 1 | Total storage capacity (tones) | 1 | 2000 |
| 2 | Value of onion @ Rs 2000/ton | 2000 | 4000000 |
| 3 | Cost of storage of onion (Rs/year)/ Repayment | 900 | 1800000 |
| 4 | Cost of sorting @Rs 70/ton | 70 | 140000 |
| 5 | Cost of electricity charges | 200 | 400000 |
| 6 | Maintenance and interest on capital | 500 | 1000000 |
| 7 | Cost of irradiation | 15 | 30000 |
| **A. Total expenditure (Rs)** | | 3685 | 7370000 |
|  | Total salable good bulbs (ton) | 0.95 | 1900 |
|  | Total salable Sprouted and black mould bulbs (ton) | 0 | 0 |
| **B.**  **Total Retur ns (Rs)** | Onion @ Rs 6000/t | 5700 | 11400000 |
| Sprouted & black mold affected bulbs @ Rs1000/ton | 0 | 0 |
| Total value (Rs) | 5700 | 11400000 |
| 8 | Net profit (Rs) (B-A) | 2015 | 4030000 |
| 9 | Net Profit (Rs/t) | 1.0075 | 2015 |

1. **COMPARISON BETWEEN EXISTING COLD STORAGE AND OUR PROPOSED CONTAINER STORAGE:**

Below table shows the comparison between existing cold storage and our proposed cold storage. From below table we infer that our proposed storage give high net profit than existing cold storage.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI No.** | **Particular** | **Cost of onion storage/ton** | **Cost of onion storage/ 30 ton** | **Our proposed architecture cost/30 ton** |
| 1 | Total storage capacity  (tones) | 1 | 30 | 30 |
| 2 | Value of onion @ Rs 2000/ton | 2000 | 60000 | 60000 |
| 3 | Cost of storage of onion (Rs/year)/  Repayment | 900 | 27000 | 21666 |
| 4 | Cost of sorting @Rs 70/ton | 70 | 2100 | 2100 |
| 5 | Cost of electricity charges | 200 | 6000 | - |
| 6 | Maintenance and interest on capital | 500 | 15000 | 8000 |
| 7 | Cost of irradiation | 15 | 450 | 450 |
| **A. Total expenditure (Rs)** | | 3685 | 110550 | 92246 |
|  | Total salable good bulbs (ton) | 0.95 | 28.5 | 28.5 |
|  | Total salable Sprouted and black mold bulbs (ton) | 0 | 0 | 0 |
| **B.** | Onion @ Rs | 5700 | 171000 | 171000 |
| **Tot al** | 6000/t |  |  |  |
| **Returns**  **(Rs)** | Sprouted & black mold | 0 | 0 | 0 |
|  | affected |  |  |  |
|  | bulbs @ |  |  |  |
|  | Rs1000/ton |  |  |  |
|  | Total value | 5700 | 171000 | 171000 |
|  | (Rs) |  |  |  |
| 8 | Net profit (Rs) (B-A) | 2015 | 60450 | 78754 |
| 9 | Net Profit | 1.00 | 2015 | 2625 |
|  | (Rs/t) | 75 |  |  |

# CONCLUSION:

In conclusion, our proposed onion storage can be a viable solution for maintaining the quality and freshness of onions, particularly for large-scale storage needs. Our container is appropriately modified and equipped with adequate ventilation, insulation, and temperature control systems to prevent spoilage, mold growth, or other quality issues that can affect the shelf life and marketability of onions. Our proposed onion storage can provide a cost-effective and practical solution for commercial growers, processors, or distributors seeking to store onions for extended periods while preserving their quality and freshness.

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