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Low-Cost Design Solution For Fruits And Vegetable Evaporative Cooling And Dehydration

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Abstract— In India 5-18% of fruit and vegetable are lost post-harvest causing economic loss to farmers. Fruits and vegetables are transported to consumers in the range of 60KMS and 1500 KMs making them expensive to the consumers and also contributing to the increased carbon footprint. As the country faces Climate change challenges and attempt zero-emission targets, it is important to address the issue of post-harvest losses and food miles. In this paper, a novel sustainable design idea to store fruits and vegetables to increase the shelf life is proposed. Dehydration of fruits and vegetables reduces the weight by 30-60%. Excess produce can be dehydrated and sent to consumers by reducing the transport cost by 20-30%. In this paper, a sustainable low-cost evaporation-based cooling chamber to preserve produce and a low-cost greenhouse dryer is proposed. The design is economic and modular when compared with highly expensive, capital-intensive solutions which are available. Experimental results of an evaporation-based cooling unit and a mini greenhouse are presented in this paper as a proof of concept.

Index Terms— Carbon Footprint reduction, Greenhouse dehydrator, Food miles, Low-cost Cold storage, Post-Harvest loss, Zero emissions.

1 INTRODUCTION

In India, the land holdings are very small and it is common for farmers obtaining 10-20 tonnes of produce of vegetables and fruits in a year. It is reported (Horticulture, 2014) that 6-13% fruits and vegetables are wasted post harvest causing great economic loss to the farmers.

Vegetables and fruits travel long distances before they reach the consumer (Rajkumar, 2010). As food travels more miles, the base price of vegetables is fixed by logistics and handling charges. When produce is more, the rates will fall drastically and only local producers will be in a position to supply and farmers who are away from the consumer centers will not be in a position to supply as rates are much below the logistics and handling charges leading to farmers dumping the produce . The cold storage and dehydration can mitigate the risk by extending the shelf life of vegetables and giving a chance to farmers to store the produce and sell when the rates are favourable. High cost capital intensive solutions are not viable and attractive to farmers. There are many large scale solutions for the cold storage and dehydration of fruits and vegetables (Roy, 2019) (Sahdev, Vol. 3 Issue 3, March - 2014).

In this paper, a very low cost modular cold storage unit based on evaporative cooling and a solar dehydrator are proposed as combination units. The cold storage unit will be a buffer storage to extend the shel-life of the produce while the dehydrator will convert the excess produce into dried vegetables and fruits with very long shelflife giving an extended opportunity for farmers to sell when the markets are favourable.

2 FOOD MILES AND POST HARVEST LOSSES

Model	Fresh vegetable Mileage in Km				
	Onion	Potato	Tomato	Egg Plant	Okra
Traditional (T)	406	1531	161	216	216
Organized (O)	570	2250	230	400	400
Difference (O - T) in Km	164	719	69	184	184
Difference (O - T) in %	40	47	43	85	85

Figure 1 Documenting Fresh Vegetable Mileage **(Rajkumar, 2010)**

2.1 Food miles In India

The term food miles indicates the distance travelled by food items before they reach the consumer. Pularajan Rajkumar (Rajkumar, 2010) has done extensive research on food miles travelled in India. His key findings are tabulated below in Figure 1.

Traditional model is where farmers book a transporter and send directly to the wholesale market. In the organized model, a middle man/ logistics provider, collects the produce from different farmers for the purpose of size consolidation and transports to the wholesale market which fetches maximum price.

The food miles contribute to the minimum base price of the produce. The logistics cost are very high and also contribute to the pollution and carbon emissions. The current transportation cost is derived from live index maintained by National Freight Index, India (INDEX, 2022).

Transportation will determine the base price of the produce. Only when the price is above the base price, famers can make an earning. In most of the cases, it becomes unviable for the farmer to even send the produce to consumer centers. The following table gives the base price contributed by transportation alone and excludes the margin money of middlemen and retailers. Table 2 has been tabulated below which indicates the minimum base prices of produce.

Vegetable	Food KM average	Base price Rs per KG
Onion	570	1.57
Potato	2250	6.23
Tomato	230	0.637
Egg Plant	400	1.1
Okra	400	1.1

Table 2 Minimum base price of vegetables is tabulated

Dry vegetables and fruit consumtion is becoming popular. Dehydration reduces the weight by 30% and contributes to the reduction of food miles. By spending same money on transportation, more produce can be sent.

We are proposing a evaporative cooling and dehydration modules as a solution to reduce the overall costs and benefit the farmer as well as the consumers.

2.2 SUPPLY SIDE DIFFICULTIES FACED BY FARMERS

Farmers with very limited cold storage facility often get into distress sales mode or abandon the produce when markets are flooded with local produce and the rates fall. In distress conditions, farmers will not get the transportation and handling charges leading to no motivation to sell their goods.

The following table presents the data collected from Chintamani town, Karnataka India. The survy data pertains to local vegetable mandi consolidator who gathers fruits and vegetables from farmers around 10 kms range. Even though Bangalore is 75 kms, they are forced to send their produce to other state locations as they do not get adequate price from Bangalore markets. We can Infer from this that a cold storage and dehydration will definitely extend the shelflife and give an additional opportunity for farmers to sell their produce when the price situation improves.

Particulars	Local Pick-up Radius	Final Transportation
Vegetables	10 KMS	Avg 75 Km (Bangalore)
Tomato	11 KMS	Avg 60 Km (Kolar, Chintamani, Mulbhagal)Outside State (400 kms)
Mango	10 KMS	Avg 60 Km (Kolar, Chintamani, Mulbhagal)Outside State (500 kms)

Table 3 Transport Methodology

3 DESIGN SOLUTION

	Live rate (₹ per ton-km)	Change vs Dec-18
All **trucks**	**2.77**	0.04%
Open	2.44	2.11%
Container	3.65	-4.15%
Trailer	2.27	5.68%

Table 1 National Freight Index (INDEX, 2022)

To address the issues of post-harvest wastage and reduce the food miles, our solution is to design a cost-effective evaporative cooling combined with dehydrator is proposed. Furthermore, dehydration of fruits and vegetables enormously increases the shelf life and reduces the weight by 60-70% reducing the transportation costs. Farmers can build modular units to store 25-50 KGS vegetables and dehydrate 25 KGS in couple of days. Based on savings and additional income, more such units can be added.

The experimental module of Evaporation based cold storage costed around Rs.5000 and Solar Dehydrator costed around Rs.50,000.By processing 1000 KGS of dried fruits and vegetable in a couple of months, farmers can recover the money.

The block diagram of the solution is given below:

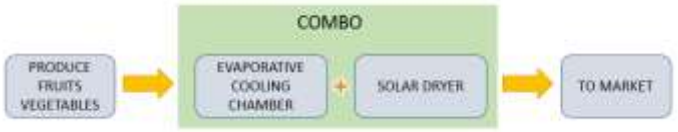
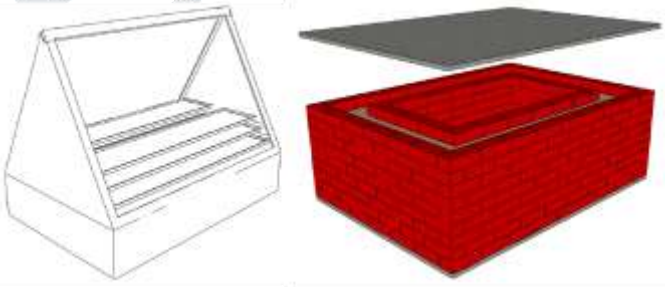


Figure 3 Block diagram of Design Solution

3.1 NOVEL LOW COST COLD STORAGE AND DEHYDRATION DESIGN



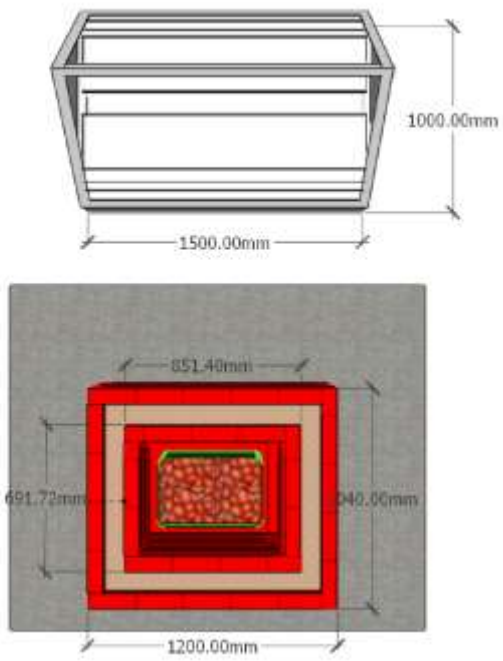


Figure 4 Above Images showing the proposed design solutions- Prototype of Dehyda-tor and cold storage unit

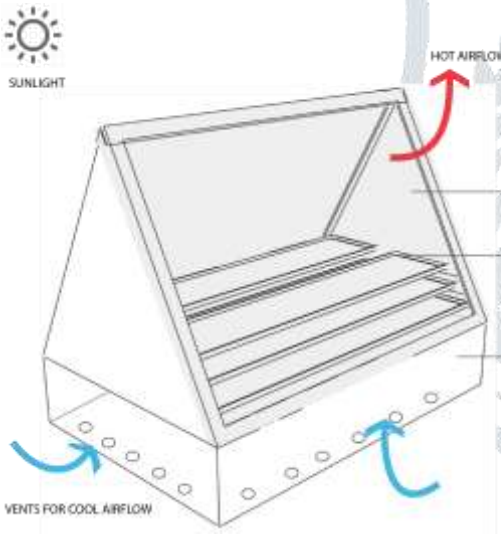


Figure 5 Solar Dehydrator

Mini greenhouse is a simple Aluminium and polythene sheet fabrication. Food trays can hold around 25kgs. Based on the type of fruits and vegetable under normal weather conditions in a month 400-600 kgs of produce can be dried. Raisins, dried ginger, raw mangoes, leafy vegetables, onions, cluster beans, French beans, tomato powder are in great demand. The solar dehydrator manufactured by Rulux Industries Bagalore, India under license from BARC India is used for the experimentation.

Figure 6 Proposed Cold storage refrigerator

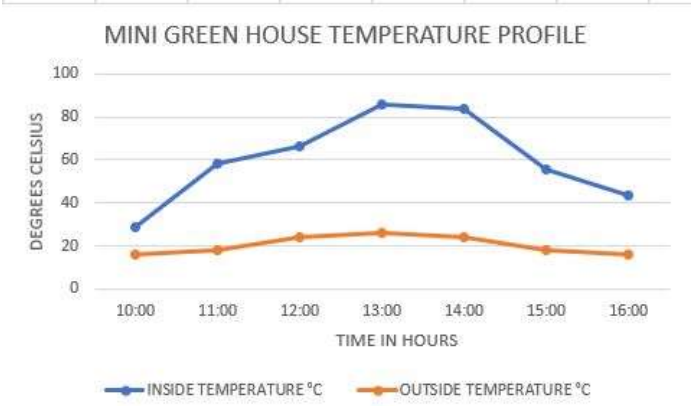
Evaporative based cold storage is a simple cost effective solution. It can create a storage environment which is 10-15 degree Celcius below the outside temperature. It consists of a storage chamber built with stacked clay bricks and an outer evaporative chamber. Between the two walled brick structure, 75mm gap is created and filled with sand. The sand layer is kept wet by sprinkling water manually or by a drip irrigation tube. Water evaporated through brick wall pores causing cooling.

3.2 Experimental Results

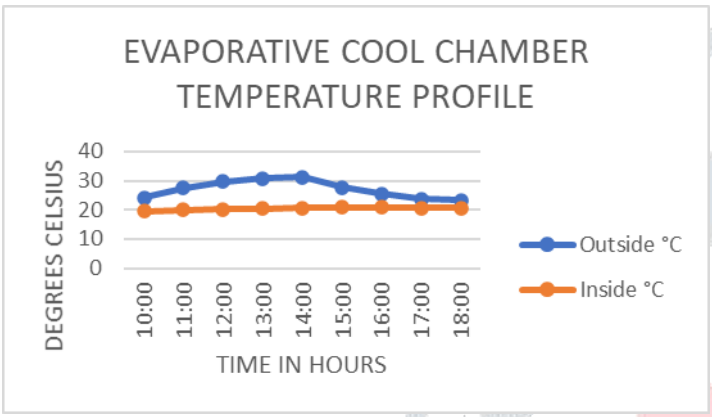
The temperature profile of prototype dehydrator (prefabricated commercially available) is given in the following figure.

Food dehydration process is well documentated (Buchanan) (Alice Henneman, 1993). The prototype temperature profile meets all the requirements for successfully drying fruits and vegetables.

The temperature profile of solar dehydrator modular unit is tabulated below.



The temperature profle of evaporative cooling chamber is given below:



Evaporative cooling can be used for Indian conditions to extend the shelflife of fruits and vegetables for several days (Mansuri) (S J Kale, 2016). The temperature profile of evaporative cooling chamber proposed meets all the requirements to successfully store fruits and vegetables.

4 Conclusion

The proposed design is a low cost and effective solution to reduce post harvest losses and helps the farmers to extend the shelflife of the produce and increase their earnings. This in turn also benefits the consumers to procure well preserved fruits and vegetables economically.

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