



# International Journal of Research in Agronomy

E-ISSN: 2618-0618  
P-ISSN: 2618-060X  
© Agronomy  
NAAS Rating: 5.20  
[www.agronomyjournals.com](http://www.agronomyjournals.com)  
2025; 8(7): 722-724  
Received: 17-05-2025  
Accepted: 19-06-2025

**ER Anurag Shrivastava**  
Assistant Professor, BRSM College  
of Agricultural Engineering and  
Technology & RS, IGKV, Mungeli,  
Chhattisgarh, India

**Astha Dixit**  
B.Tech, BRSM College of  
Agricultural Engineering and  
Technology & RS, IGKV, Mungeli,  
Chhattisgarh, India

**Navneet Kumar**  
B.Tech, BRSM College of  
Agricultural Engineering and  
Technology & RS, IGKV, Mungeli,  
Chhattisgarh, India

**Corresponding Author:**  
**ER Anurag Shrivastava**  
Assistant Professor, BRSM College  
of Agricultural Engineering and  
Technology & RS, IGKV, Mungeli,  
Chhattisgarh, India

## Solar based integrated cooling and ripening system for fruits and vegetables

**ER Anurag Shrivastava, Astha Dixit and Navneet Kumar**

**DOI:** <https://www.doi.org/10.33545/2618060X.2025.v8.i7i.3270>

### Abstract

A sustainable, economical, and environmentally responsible approach for reducing post-harvest losses and improving the quality of agricultural products is the solar-integrated cooling and ripening system for fruits and vegetables. Fruits and vegetables often degrade rapidly in many rural and off-grid areas due to limited access to safe ripening technology and reliable cold storage. This integrated system provides an effective, off-grid alternative to traditional methods by harnessing solar energy to power both the cooling and ripening chambers within a single unit. The cooling chamber utilizes thermoelectric Peltier modules to maintain low temperatures, extending the shelf life of perishable goods and keeping their freshness. Instead of hazardous chemicals like calcium carbide, the ripening chamber mimics natural ripening conditions through carefully controlled temperature and humidity. To ensure continuous operation during non-sunny periods, both chambers are powered by a 20W photovoltaic solar panel connected to a 12V, 4.5Ah battery. Small-scale farmers, fruit vendors, and rural business owners particularly benefit from this system, as it provides a versatile tool that functions without grid electricity. Preserving fruit and vegetable quality not only increases their market value but also promotes environmental sustainability and food safety. The system's compact design, low operational costs, and minimal maintenance requirements make it ideal for decentralized agricultural ripening and storage. Overall, this prototype demonstrates how renewable energy can be used in a cost-effective and environmentally sustainable way to enhance post-harvest handling of fruits and vegetables.

**Keywords:** Solar system, ripener, food processing

### Introduction

India ranks among the top producers of fruits and vegetables worldwide, yet a significant portion of this supply is wasted after harvest due to poor ripening techniques and inadequate storage facilities. Fruits and vegetables are examples of perishable agricultural products that are highly sensitive to environmental factors and quickly lose quality if not stored properly <sup>[1]</sup>. Besides lowering farmers' incomes, these losses harm the country's food security and agricultural supply chain <sup>[2]</sup>. Off-grid or rural areas often lack access to traditional cold storage and ripening systems because they tend to be costly, energy-intensive, and reliant on continuous electrical power. For smallholder farmers and vendors, this limitation presents a major challenge, especially in regions without reliable electricity <sup>[3]</sup>. A decentralized, affordable, and sustainable system capable of preserving agricultural products without grid electricity is urgently needed. This paper examines the design, development, and evaluation of a solar-integrated cooling and ripening system that uses Peltier plates (thermoelectric modules) for temperature regulation, addressing this issue. Powered by solar photovoltaic (PV) panels and independent of traditional grid electricity, this technology is suitable for rural and remote regions <sup>[4-8]</sup>. Peltier modules are ideal for small-scale applications because they are compact, quiet, have no moving parts, and require minimal maintenance, unlike compressor-based refrigeration units <sup>[9-10]</sup>. The system's main functions are to maintain low temperatures for cooling and to control humidity and temperature levels for ripening climacteric fruits such as bananas and mangoes. It enables uniform, chemical-free ripening and extends the shelf life of fresh produce by creating a controlled environment. This dual-purpose approach reduces food waste and enhances product quality <sup>[11]</sup>. The primary goal of the study is to design and evaluate the system's performance under real-world conditions, particularly in rural settings. The evaluation considers key factors

such as energy consumption, internal temperature and humidity control, fruit quality after cooling and ripening, and overall system efficiency. By providing an affordable and environmentally friendly post-harvest management solution, the project aims to increase farmers' profits and strengthen regional food supply chains. The scope of the study includes the use of solar panels as the main energy source, Peltier modules for cooling, and practical testing with specific fruits and vegetables. The system's impact on product shelf life and its ability to maintain targeted environmental conditions form the foundation of the assessment.

### Methodology and Materials

The solar-integrated cooling and Ripening System is a small, environmentally friendly, two-chamber fruit and vegetable post-harvest management tool. The block diagram shows the proposed methodology for our study in Figure 1.

### Components used

**Solar panel:** The main energy source for the Peltier modules, fans, and sensors in the cooling and ripening unit is the solar panel, which has a maximum power output of 20W, 17V voltage, and 1.16A current in ideal load condition.

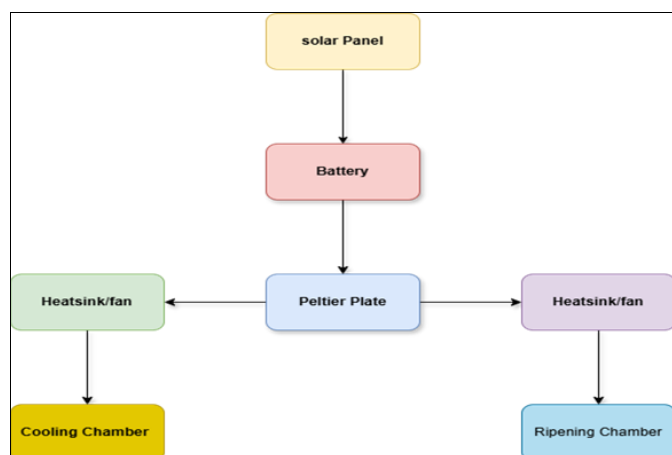


Fig 1: Block diagram of the working model of the solar-integrated cooling and ripening system.

**Battery:** For continuous functioning of the Peltier module, fans, and sensors even in the absence of sunlight, the 12V, 4.5Ah rechargeable battery stores solar energy.

**Peltier Plate:** Operating at up to 12V and 6.4A, the TEC1-12706 Peltier module (40mm × 40mm × 3.6mm) produces a temperature differential using the Peltier effect and is perfect for small, portable cooling applications.

**Heat Sink:** The 18×6.5×1 cm and 10×6.5×1 cm heat sinks, made of thermally conductive materials like copper or aluminium, passively disperse heat by increasing surface area for efficient thermal transfer.

**Fans:** The KS 8025 H CPU fan (80×80×25mm) is a small, effective cooling fan made to improve heat dissipation in small areas. It runs at 12V and 0.18A and has a typical speed range of 2000-3000 RPM.

**Mini LCD Digital Thermometer:** A temperature sensor with display is a little gadget that monitors the surface or ambient temperature and displays the reading in real time on an LCD or

digital screen that is attached.

**Toggle switch:** Toggle switches are basic electromechanical switches that operate by swinging a lever back and forth to open or close an electrical circuit.

**Thermocol Chamber:** This insulated, lightweight enclosure, composed of expanded polystyrene (EPS), reduces heat transmission and helps to maintain constant internal temperatures for efficient fruit and vegetable ripening and cooling.

The front view of the prototype is shown in Figure 2. The model is designed in such a way that the cooling side of peltier plate is connected to the cooling chamber, whereas the heat sink is connected to the ripener chamber. The solar panel is used as a power source that makes the model portable and can be installed with ease as well.

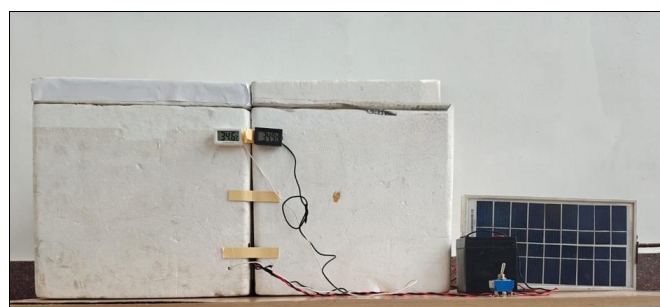


Fig 2: Front View of Developed Model

### Results and Discussion

The system's ability to sustain ideal temperatures inside insulated chambers is shown in Figure 3, the temperatures were recorded at different time intervals as shown in Figure 3, at initial level both the chambers show the same temperature of 35°C after the time interval of 25 minutes the optimum temperature at the cooling side of the Peltier plate was recorded to be 24 °C whereas that of ripening side recorded to be 44°C.

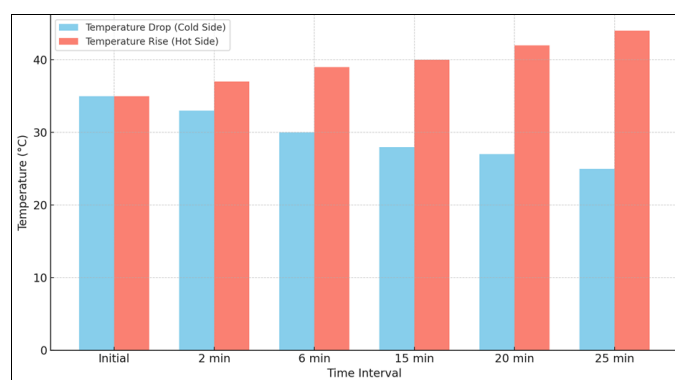


Fig 3: Temperature variations

### Economic and Environmental Impact

Because it runs on clean solar energy and doesn't use hazardous refrigerants like HFCs or CFCs or produce greenhouse gases, the solar-integrated cooling and ripening system offers significant environmental benefits. Its decentralized design allows it to operate quietly, use no water, generate minimal waste, and be ideal for deployment in rural areas. By reducing post-harvest losses, providing low operating costs, requiring little maintenance, and improving food quality and income

stability, it benefits small farmers and sellers economically.

## Conclusion

In rural areas, the solar-integrated Peltier cooling and ripening system offers an affordable and eco-friendly way to preserve produce. It supports global climate goals by using clean solar energy, avoiding harmful refrigerants, and producing no emissions. The system extends the shelf life and improves the quality of produce while running quietly, requiring minimal maintenance, and not relying on fossil fuels. Its low cost, ease of use, and decentralized operation make it ideal for small-scale farmers and merchants. Additionally, it helps reduce post-harvest losses and ensures long-term financial benefits.

## References

1. Amjad W, Munir A, Akram F, Parmar A, Precoppe M, Asghar F, Mahmood F. Decentralized solar-powered cold storage systems for smallholder farmers: A review. *Renew Sustain Energy Rev.* 2023;150:111456.
2. Dhumal GS, Deshmukh PA, Kulkarni ML. Experimental and mathematical modelling of thermoelectric refrigeration system based on solar energy. *Int Eng Res J (IERJ).* 2015;1(3):1834-1838.
3. Gabriele C, Tan YK, Lee CP. Viability of Cold Thermal Energy Storage (CTES) in hot climates for building demand management. *Energy Build.* 2018;165:285-294.
4. Leni D, Fu Z, Sitorus TB. Development and evaluation of a solar-powered cold storage prototype using thermoelectric cooling system. *J Renew Energy Sustain Dev.* 2024;10(1):45-53.
5. Murthy KPS, Rakshitha, Santhosh, Vinutha, Pallavi. Development of solar-powered cold storage devices using Peltier modules. *Int J Innov Res Sci Eng Technol.* 2024;13(2):123-130.
6. Nakhate P, Pawaskar N, Vatamwar P, Kalambe S. Ecofriendly refrigerator using Peltier device. *Int J Eng Sci Res Technol.* 2016;5(4):123-128.
7. Nandini KK, Muralidhara. Peltier based cabinet cooling system using heat pipe and liquid based heat sink. In: *Proc Natl Conf Challenges in Res Technol Coming Decades (CRT 2013)*.
8. Pushkarny BH, Patel D, Parulkar A, Rai H, Khan N. Solar refrigeration using Peltier effect. *Int J Sci Res Sci Technol.* 2017;3(2):456-460.
9. Shelke D, Shelke M, Kokane T, Chougule N, Yenare RR. Solar refrigeration using thermoelectric modules. *Int J Eng Res Gen Sci.* 2014;2(3):2348-2349.
10. Sitorus TB, Lubis Z, Sembiring F, Christopel B, Siagian JAR. Utilization of Peltier cooling systems driven by solar power for storing vegetables and fruits. *IOP Conf Ser Mater Sci Eng.* 2020;725(1):012014.
11. Xu Y, Zhang L, Li H. Experimental investigation of solar photovoltaic operated ice storage air conditioning system. *Renew Energy.* 2019;135:1235-1245