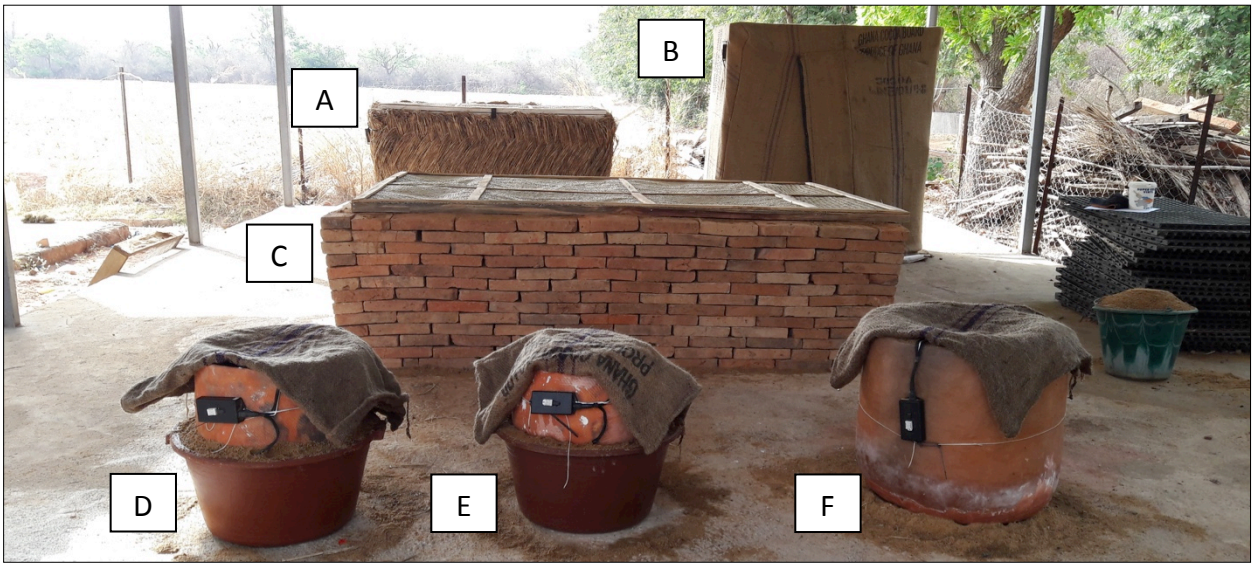
EXECUTIVE SUMMARY: Evaluation of Low-Cost Vegetable Cooling and Storage Technologies in Mali

In Mali, the horticulture sector plays an increasing vital role in human nutrition and health, income generation for farmers, and poverty alleviation. A lack of affordable and effective post-harvest storage solutions often leads to vegetable spoilage, loss of income, lack of access to nutritious foods, and large amounts of time spent to purchase vegetables, particularly in rural communities. The challenges faced by the horticulture sector in Mali are prevalent in many other developing regions where farming is the predominant source of income and food for populations who lack access to affordable electricity for proper cooling and storage of vegetables and leafy greens.

The objective of this research study is to investigate the potential for non-electric vegetable cooling and storage devices to address the post-harvest storage challenges in rural Mali. The two classes of devices evaluated in this study were commonly known as “Zero Energy Cooling Chambers (ZECCs)” and “Zeer pots”, which are generally used by horticulture cooperatives and households, respectively. Such devices rely upon the evaporation of water to create a cooling effect and their performance is significantly impacted by the ambient temperature and humidity of the environment where they are operating.

In this study, we used a combination of electronic sensors and structured user interviews to gather information about users’ needs for improved post-harvest vegetable storage, current methods of post-harvest vegetable storage, and the performance of the evaporative cooling devices.



Below is an image of the three ZECCs and three Zeer pot evaporative cooling device types included in this study: A) Straw ZECC, B) Sack ZECC, C) Brick ZECC, D) Cylinder pot-in-dish, E) Round pot-in-dish, and F) Pot-in-pot.

Results

The results of this study indicate that evaporative cooling devices such as Zeer pots and ZECCs have the potential to benefit both off-grid, who have limited electricity access, and on-grid populations, who face high electricity and/or equipment costs for refrigerators, by providing a low-cost option for improved vegetable cooling and storage. Evaporative cooling can reduce post-harvest losses of vegetables through the following mechanisms:

- Stable storage environment with low temperature and high humidity reduces water loss and spoilage for most vegetables
- Protection from animals and insects that contaminate and eat the vegetables

The reduced post-harvest losses – achieved through the improved storage environment – can lead to impacts including monetary savings, less time spent traveling to the market, and increased availability of vegetables for consumptions.

Our comparison of ZECCs made of different materials demonstrate that ZECCs made of brick are superior to ZECCs made of straw or burlap sacks, providing a more stable low temperature and high humidity environment, along with being easier to water and providing protection from animals and insects.

When comparing Zeer pots, devices with the pot-in-pot configuration provided a greater temperature decrease than the Zeer pots with the pot-in-dish configuration. Both devices performed very similarly on other metrics such as interior humidity, ease of watering, and protection from animals and insects. These results indicate that there are relatively loose design constraints for constructing a Zeer pot that provides a basic level of performance, even if not optimized, creating an opportunity for locally available materials to be repurposed to create an effective Zeer pot for vegetable cooling and storage. Most of participants (90%) reported that they were no longer using any of their previous storage methods after receiving the Zeer pots, indicating that the 50 liter capacity of the Zeer pots used in this study is sufficient to meet the vegetable storage needs of most households.

Summary of key characteristics for each evaporative cooling device

Evaporative cooling device	Average temperature decrease*	Interior humidity range*	Minimum watering frequency	Protection from animals and insects	Storage volume	Cost
ZECC (straw)	5.4 °C	30-50%	1-3 times per day	No	250-4000 L	$50 - $250
ZECC (sack)	2.6 °C	10-30%	1-3 times per day	No	250-4000 L	$50 - $250
ZECC (brick)	5.8 °C	80-100%	once per 1-7 days	Yes	500-5000 L	$70 - $350
Round pot-in-dish	5.1 °C	80-100%	once per day	Yes	10-150 L	$6 - $35
Cylinder pot-in-dish	4.7 °C	80-100%	once per day	Yes	10-150 L	$6 - $35
Pot-in-pot	6.7 °C	80-100%	once per day	Yes	10-100 L	$10 - $50

*For the data provided, the ambient relative humidity was less than 40% and the average daily ambient temperature was between 29 °C and 37 °C.

Recommendations

The most important first step is for prospective users, producers, or promoters of ZECCs and/or Zeer pots to carefully consider the suitability of evaporative cooling devices for the specific context of interest, by answering the question: *Does the technology effectively meet the needs of the intended users?*

The following factors should be assessed in order to determine if the suitability of evaporative cooling devices for a specific context:

- **Operating conditions:** Specific conditions are required for evaporative cooling devices to effectively operate
- **Need:** The needs of a user must be addressable by the storage conditions that evaporative cooling can provide
- **Value:** The cost of the ZECC or Zeer pot must be affordable and justified by the benefits that will be realized due to the improved storage

If evaporative cooling devices have been determined to be suitable for a given context, the key elements for increasing the usage of evaporative cooling devices are awareness, availability, quality, and affordability in the specific region. If evaporative cooling devices have the potential to meet the vegetable cooling and storage needs in a community or region, the following steps should be taken in order to increase the dissemination of these beneficial technologies:

- Identify end-users who could benefit from evaporative cooling technologies
- Raise awareness of the benefits of the technology among prospective end-users
- Increase availability of appropriately designed clay pots; organized production and distribution can increase availability, quality, and affordability

Additionally, we have created an interactive *"Decision making tool"* and a "*Best practices guide*" to support the determination of suitability of ZECCs and Zeer pots for a specific context, and proper construction and usage of the devices. The intended audience for these resources includes government agencies, NGOs, civil society organizations, and businesses that could produce, distribute, and/or promote ZECCs or Zeer pots.

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