

EVAPORATION: THE ZEER POT



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Electricity Free Refrigerator

This report explores the science and myths surrounding the Zeer Pot. This ancient technology has recently been rediscovered and popularized resulting in everything from factual claims and well documented science to purely fictitious and misleading misinformation.

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PHYSICS 1010

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Evaporation: The Zeer Pot

THE ELECTRICITY FREE REFRIGERATOR

The History of The Zeer Pot

The Arabic word "zeer" means large pots. The concept of cooling water and other items in clay pots can be dated back to Egypt around 2500 B.C. where frescos show slaves fanning large clay pots. This type of evaporative cooling has also been used by the Indus Valley Civilization that existed around 3000 B.C. in the areas known today as northeast Afghanistan and Pakistan and northwest India.

Despite being redeveloped in northern Africa in the 1990's by Mohammad Bah Abba, the practice of using Zeer pots has been discarded with the discovery of modern day refrigeration. The resurgence of this technology has been introduced throughout Nigeria as the "Desert Refrigerator" which proves highly effective in dry, hot climates of many African countries to preserve the shelf life of perishable foods. Abba developed an educational campaign aimed at local villagers and the remote illiterate populations to explain the benefits of the desert refrigerator which is sold there for \$2.00 (USD) per unit. [1]

The Immediate Benefits

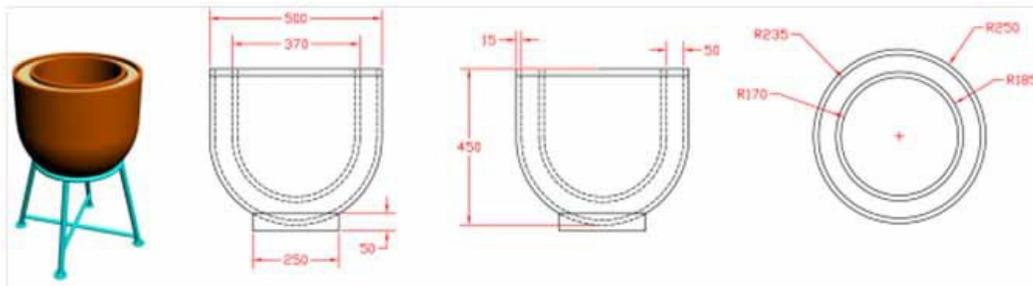
In dry climate areas, crop yields are a valuable commodity that can quickly turn to waste without proper refrigeration to extend its shelf life. With the use of the pot-in-pot cooler shelf life can be extended 5 to 10 times. Not only does it benefit the farmer, who can offer his unsold crops on the market for a longer period, but also extend shelf life for the consumer. (See Table 1)

Produce	Shelf-Life without Zeer	Shelf-Life with Zeer
Tomatoes	2 days	20 days
Guavas	2 days	20 days
Okra	4 days	17 days
Carrots	4 days	20 days
Arugula	1 day	5 days

Table 1: Shelf-life with and without Zeer pot refrigerator [2]

Zeer Pot Construction

A zeer is constructed by placing a smaller clay pot into a larger clay pot. Sand is placed between the interior of the large pot and the exterior surface of the small pot. Water is then poured into the sand and a damp cloth is placed over the opening of the pots. Under well ventilated, low humidity conditions, the inner chamber of the zeer is cooled as the water in the sand evaporates drawing warm air from it. Perishable items stored in the cooled inner chamber can extend shelf well beyond normal conditions.



For less than \$2.00 (USD) a clay pot system can cool up to 12 kg of produce. [3]

How It Works

When evaporation occurs from a surface, there is an energy associated with the phase change known as the latent heat of vaporization. In a given system, as a gas flows over the wet surface, evaporation and condensation continuously occur to maintain steady-state conditions.

In order to sustain evaporation, there must be a draw of internal energy in the liquid, which would result in a temperature reduction. This cooling effect is known as evaporative cooling and is most effective in dry climates due to the lack of moisture content (relative humidity) in the air.

In the case of the Zeer refrigerator, water evaporates out of the sand through the surface of the outer clay pot and from the whole top surface of the moist sand exposed to the solar radiation, removing energy from the system. Figure 1 and Figure 2 are graphical representations of the water and energy flow within a Zeer refrigerator.[2]

Please take a moment to view a video using the hyperlink below: (Press <Ctrl> + click to follow link)[4]

https://www.youtube.com/watch?feature=player_embedded&v=ZNLPeB3qIhc

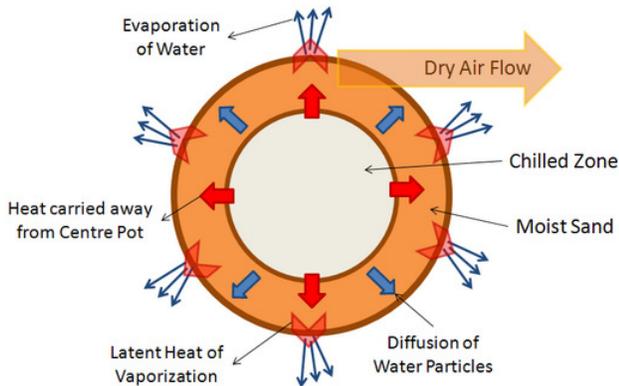


Figure 1 (Top View)

Conceptual Flow of Energy and Water in a Zeer Cooler [2]

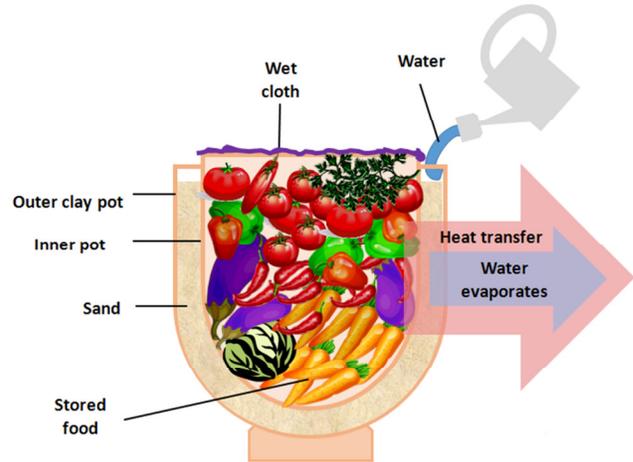


Figure 2 (Front - Section View)

Functioning of a Clay Pot Cooler [1]

Why Doesn't Everyone Own a Zeer Pot?

Without a doubt, the zeer pot is an ingenious, yet simple invention that harnesses the laws of thermodynamics to provide an inexpensive method of cooling, thus preserving food in hot, dry climates. Many claims have been made about its benefits and effectiveness, but regardless, the zeer pot does have its limitations and must obey the laws of physics. Compared to modern methods of refrigeration which keeps our food at a cool 40F degrees, the zeer pot has a very narrow margin of effectiveness. There are some websites and Youtube videos that claim the zeer pot can keep food cool at a steady 6 degrees Celcius (43 degrees F), but they fail to mention the conditions required to maintain that level of cooling. (See Table 2) [5]

Conditions under which an evaporative refrigerator could reach 6 degrees C (43 degrees F)

Outside Temperature: Degrees - Celsius(Fahrenheit)	Relative Humidity
20.5C (69F)	0%
18.3C (65F)	10%
15.3C (59F)	20%
13.3C (56F)	30%
12.2C (54F)	40%
10.5C (51F)	50%

Limitations of Device

Beyond the limitations of the required climatic conditions for the pot-in-pot refrigerator to be successful, there is also a need for a continuous supply of water. For many regions, water may be prioritized for other purposes making it difficult for communities to adopt the technology. The device also has no proper seal for the storage chamber, reducing its overall effectiveness since warm ambient air can seep into this chamber and increase the temperature of the chilled zone. (however warm air will rise and chilled air is heavier and drops, so the temperature will always be coldest on the bottom)

Conclusions

A parametric analysis concerning the performance of a Zeer pot-in-pot refrigeration device has been performed. As expected, the device performs well only in climates possessing a low relative humidity. The velocity of the wind and the area available for evaporation to occur on/through are two primary factors that can be addressed to improve the performance of the pot-in-pot refrigerator.

It has been shown that increasing the radius of the outer pot from 0.25m to 0.45m, almost doubles the total cooling effect. The adaptation of this however, is restricted by the increase in cost associated with using more materials. It is suggested that the strategy to make larger pot-in-pot refrigerators be employed only if community members are willing and able to pool their resources to share a device with superior performance.

It is unrealistic to assume that electricity is available to ensure that there is a constant and adequate source of air flow. The device is dependent solely on naturally occurring winds. To maximize air flow, it is recommended that the Zeer refrigerator be placed as high above the ground as possible. This can be accomplished by building a simple frame to support the device, and placing them on high ground or on top of buildings.

There remains the potential for future analysis of this device. The development of a detailed conduction model to analyze heat transfer and mass diffusion mechanisms within the various layers would aid in identifying factors limiting performance and how they can be addressed. Additionally, by experimentation, a study could be performed to replace the permeability correction factor used in this analysis with real diffusion rates of moisture through clay. [3]

Works Cited

- [1] Unknown. "Pot in Pot Refrigerator." Wikipedia; Last modified, 2 November 2014
- [2] Peter Rinker. "Zeer pot refrigeration (design)." Appropedia; Last modified, 6 August 2014
- [3] Unknown. "Zeer pot fridge." Practical Action; Last modified, Undated
- [4] Ravindra Krishnamurthy. "Zeer Pot: Demonstration of Effectiveness." The Permaculture Research Institute; Posted, 28 April 2014
- [5] Unknown. "Busting myths about the Zeer pot." Rebuilding Civilization; Last modified, Undated