CLAY POT COOLERS
Preserving Fruits & Vegetables in Mali

Report 2016-2021:
Suitability evaluation, lab testing, training, and dissemination

MIT D-Lab Evaporative Cooling Research Group

October 2021

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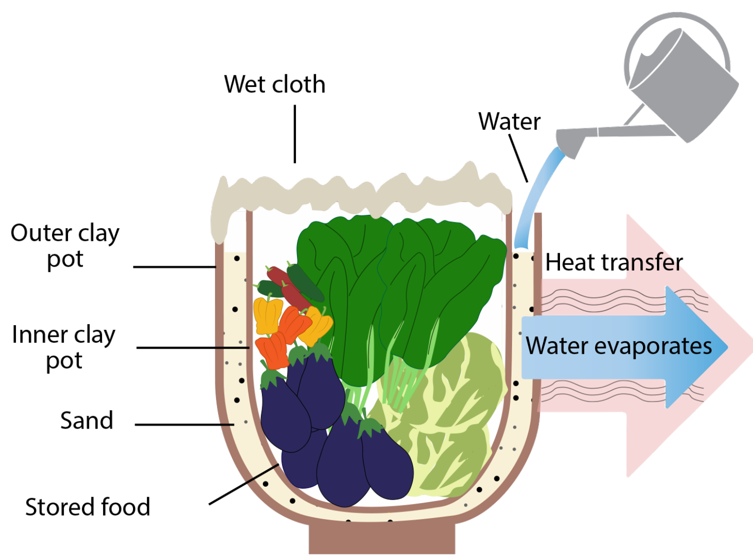
Clay Pot Coolers: Project Overview

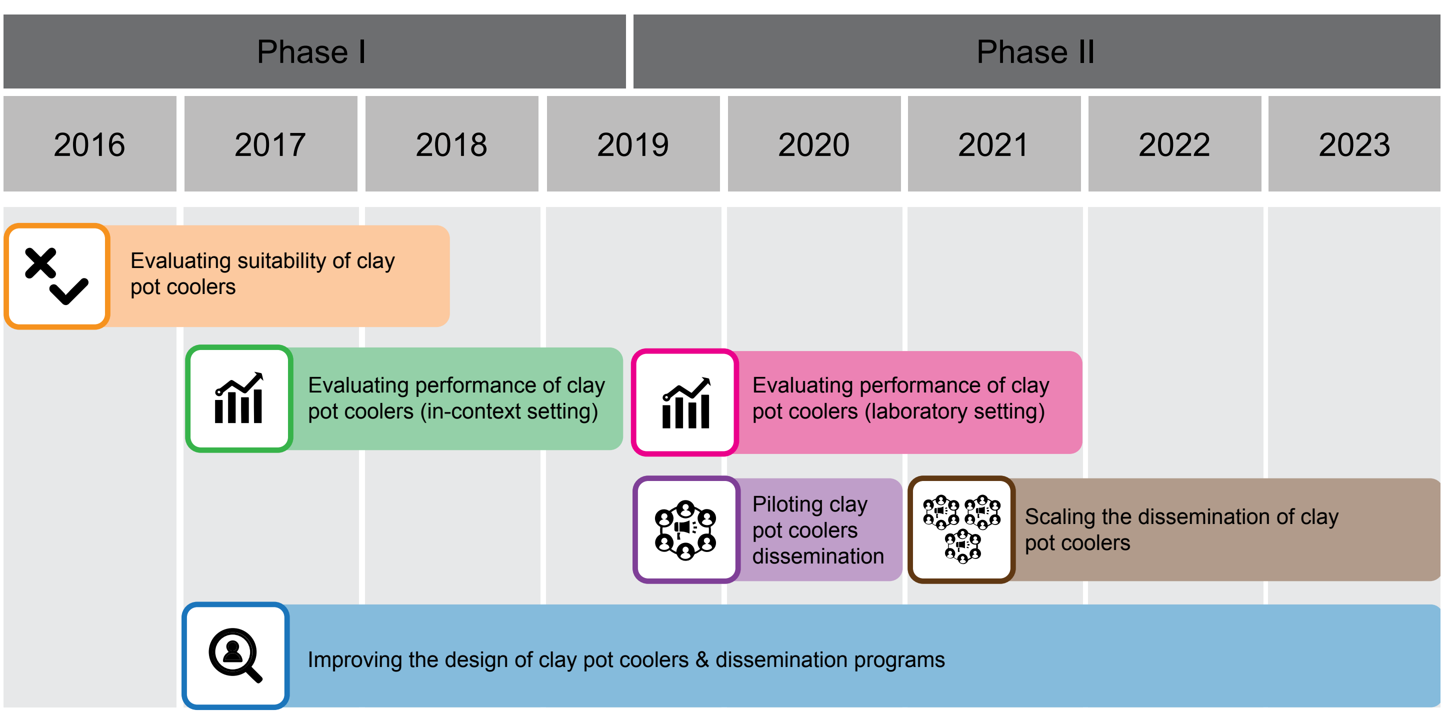
Food, water, and electricity are considered basic needs by many, but these are still luxuries to many people around the world. Imagine spending up to an hour walking to purchase vegetables every day because you don't have a way to store vegetables that keeps them fresh and pest-free. This is exactly what happens to many people in communities where access to electricity or affordable vegetable preservation methods are limited. In Sub-Saharan Africa alone, 30% to 50% of fruits and vegetables harvested are lost before reaching the consumer.

One way this problem can be addressed is through the promotion and use of clay pot coolers for storing and preserving fruits and vegetables. They are an affordable and accessible solution that use evaporation for cooling and do not require electricity to run. The most common clay pot coolers, or "Zeer pots," are made of a double-wall earthenware container with the space between the two clay walls filled with wet sand. When the water from the outer surface evaporates, the inside of the container—where the vegetables are stored—is cooled.



Clay pot cooler schematic based on work by Peter Rinker, Movement e.V. and redesigned by Melissa Mangino.

While clay pot coolers and other evaporative cooling technologies have been shown to effectively increase the shelf life of many fruits and vegetables, these technologies have not gained widespread adoption. This is due to the lack of product evaluations based on real-world scenarios and user behavior to inform the design of dissemination programs. MIT D-Lab's Evaporative Cooling research group aims to bridge this gap and increase the dissemination of clay pot coolers in appropriate contexts. The D-Lab clay pot cooler project started in 2016 and has consisted of multiple phases (see graphic below), each focusing on a different technical and social aspect of this technology.



Evaluating Suitability and User Needs

Clay pot-in-pot cooler in Bankass, Mali. Photo: Ousmane Sanogo

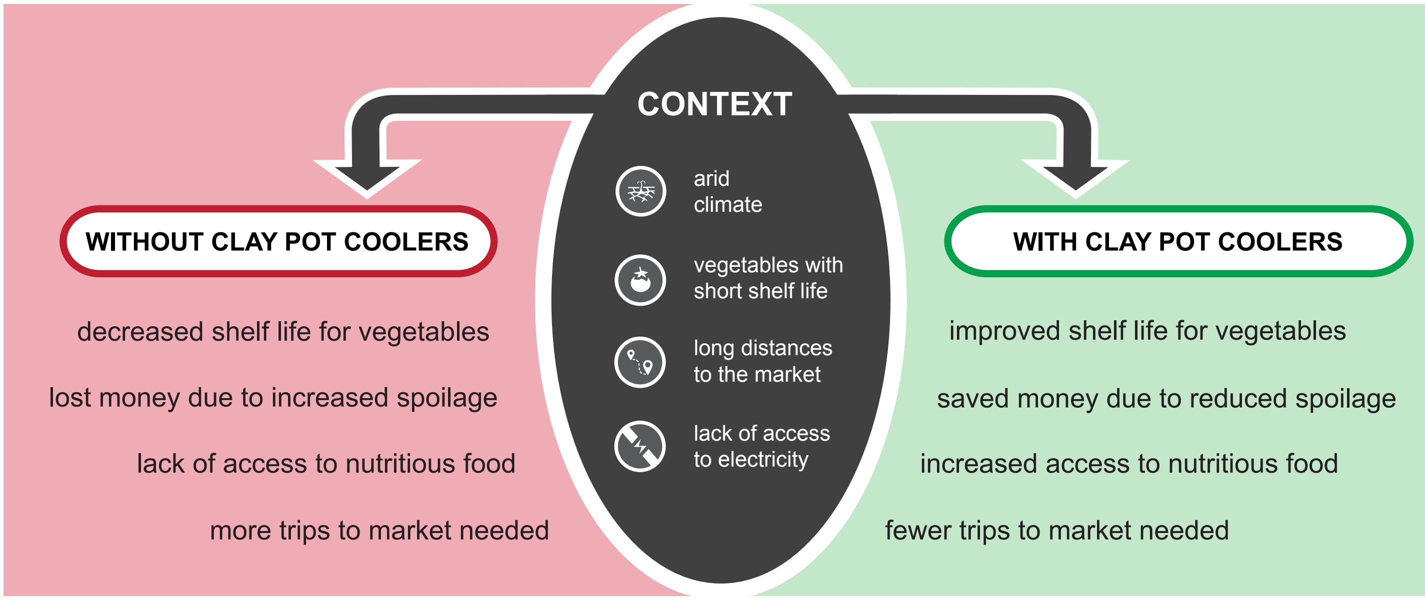
Clay pot-in-plastic dish cooler in Samanko, Mali. Photo: Ba Germain Diarra

Although clay pot coolers and other evaporative cooling technologies have the potential to address challenges related to post-harvest food loss in rural communities, it is important to determine the appropriateness of these solutions by having the target users test the product in their environment. In 2017, with funding from the United States Agency for International Development (USAID), MIT D-Lab worked with the World Vegetable Center (WVC) and Institut d'Economie Rurale (IER) to explore the potential for clay pot coolers to address post-harvest loss challenges faced by communities in Mali, a landlocked country in West Africa. The initial study focused on evaluating the performance and suitability of this technology by providing study participants with a clay pot cooler for use in their homes.

Ousmane Sanogo (left) training a man on pot watering in Bankass, Mali. Photo: Ousmane Sanogo

Through conversations with clay pot sellers during initial scoping for the project, the team learned about a design variation with a clay pot inside a plastic or metal dish. This design was included as part of the study, in addition to the more common clay pot-in-pot or "Zeer pot" design.

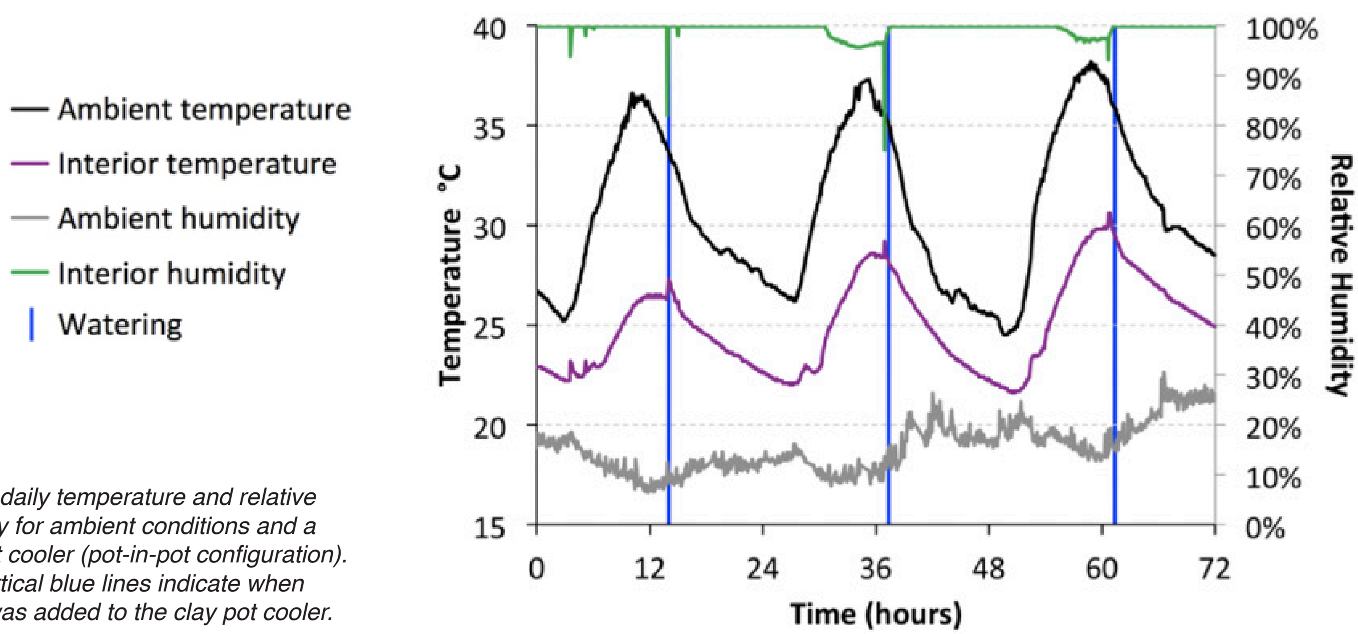
After a brief introduction to clay pot coolers and the objectives of the study, the participants were asked to use a clay pot cooler provided to them for a minimum of three months, after which they were interviewed to collect qualitative data on their needs for post-harvest storage and preservation. Quantitative data on the performance of the clay pot cooler was obtained through electronic sensors attached to each clay pot cooler, which measured the ambient and interior temperature and humidity of the clay pot cooler at five-minute intervals.



Storing vegetables with a short shelf life in places like Mali, with an arid climate and scarce access to electricity, is challenging. However, the study revealed that clay pot coolers increased the shelf life of vegetables by providing a stable storage environment with low temperature and high humidity.

The most commonly stored vegetables were eggplant, tomato, hot pepper, cucumber, cabbage, and sweet potato leaves, and 97% of participants reported improved shelf life for one or more of these vegetables when they were stored in a clay pot cooler. During the dry season, the average temperature in the interior of the clay pot coolers was 5 °C to 7 °C lower than the ambient temperature and maintained a relative humidity above 80%. During the dry season, the average temperature in the interior of the clay pot coolers was 5 °C to 7 °C lower than the ambient temperature and maintained a relative humidity above 80%. The cooling effect is most pronounced during the middle of the day, with reduction between 7 °C to 10 °C, when the temperature is the highest, the relative humidity is the lowest, and vegetables are most susceptible to spoilage. Furthermore, the participants revealed benefits that came with using the clay pot cooler such as financial savings due to reduced food loss, less time and money spent traveling to the market, increased availability of nutritious vegetables for their families, improved hygiene of the vegetables, and protection from animals and insects.

The combination of results from the performance study and user feedback indicated that both the clay pot-in-pot and the clay pot-in-plastic dish coolers are a suitable and effective solution for many households in Mali.



Typical daily temperature and relative humidity for ambient conditions and a clay pot cooler (pot-in-pot configuration). The vertical blue lines indicate when water was added to the clay pot cooler.

Lab Testing and Shelf Life Measurements

In order to rigorously quantify the shelf life improvements that clay pot coolers provide for various vegetables, the research team conducted laboratory experiments with 14 configurations of clay pot coolers and other evaporative cooling devices at two locations. The vegetables selected for the study were spinach, amaranth, cowpea leaves, tomatoes, and eggplants. The analysis techniques used included weight loss measurements, visual assessment by 10-person panels, and sensors measuring the temperature and humidity of the clay pot cooler interior and ambient conditions.

Miriam Sogoba of World Vegetable Center conducting shelf-life measurements for spinach in Samanko, Mali. Photo: Eric Verploegen

	AMBIENT CONDITIONS	CLAY POT-IN-PLASTIC DISH	CLAY POT-IN-CLAY POT
Average temperature	26.9 °C	22.7 °C	22.2 °C
Maximum daily temperature	34.6 °C	26.2 °C	25.8 °C
Average humidity	45%	96%	94%
Amaranth shelf life	1 day	6 days	6 days
Spinach shelf life	2 days	6 days	6 days
Cowpea leaf shelf life	1 day	4 days	4 days
Tomato shelf life	6 days	9 days	9 days
Eggplant shelf life	3 days	15 days	>15 days

Table 1. Shelf life determined from the visual quality assessment data. For leafy greens, data was collected at 1, 2, 4, and 6 days after the start of the experiment. For tomatoes and eggplants, data was collected 3, 6, 9, 12, and 15 days after the start of the experiment. A vegetable was determined to have a shelf life of the number of days listed in the table if more than 50% of the panel members assessing its overall visual quality scored it as > 5 using the 1–9 rating scale developed by Kader and Cantwell (2005), where 1 = extremely poor quality (not usable), 3 = poor quality (serious deterioration, limit of usability), 5 = fair quality (deterioration evident, but not serious, limit of saleability), 7 = very good quality (minor symptoms of deterioration, not objectionable), and 9 = excellent quality (essentially no symptoms of deterioration). The temperature and humidity data shown was collected during the leafy green shelf life experiments.

As shown in the table above, clay pot coolers extended the shelf life of vegetable by 50% to 600% compared to storage in ambient conditions.

This improvement is possible because the clay pot coolers reduced the average temperature by over 4 °C and provided an environment with greater than 90% humidity, while the average ambient humidity is 40%. Furthermore, the clay pot coolers reduced the maximum daily temperature of the vegetables by more than 8 °C, protecting the vegetables from the most damaging ambient conditions of the day.

The research team also tested devices consisting of a metal or plastic bucket in a clay dish and a plastic vegetable crate covered with a wet sack. While vegetables stored in these devices were kept fresh longer than those stored in ambient conditions, the shelf life was several days shorter than the clay pot-in-pot and clay pot-in-dish devices, which have a clay pot as the interior vessel.

Dissemination

Clay pot cooler training at the Anya-Lobo Cooperative Society in Mopti, Mali. Photo: Djiguiba Boureima

Dissemination Approach & Training

The dissemination phase of the project includes designing and implementing training programs to increase awareness and usage of clay pot coolers. In order to promote the adoption of this technology, it is important that users feel confident about buying or constructing clay pot coolers themselves and using them. Entrepreneurs looking to sell clay pot coolers need to feel confident in their marketing strategies.

Based on the learnings from the earlier phases of the project and the experiences of others in the sector, the team (MIT D-Lab, WVC, and IER) developed a curriculum covering:

- How evaporative cooling works
- Importance of proper fruit and vegetable storage
- Types of clay pot coolers and how to assemble them
- Best practices for using clay pot coolers

The dissemination approach starts by sharing this curriculum with agricultural extension agents and clay potters through in-depth Training of Trainers (ToT) sessions. These folks then deliver the curriculum to larger groups of vegetable sellers, pot makers, farmers, and other community members through streamlined training sessions.

The first ToT was conducted in January 2020 with Djiguiba Boureima, Extension Officer, Regional Directorate of Agriculture, Mopti; and Kadidia Nienta, a pot maker and seller in Mopti, Mali.

In March 2020, Boureima and Kadidia then trained 37 people at the Nyleni and Anya-Lobo cooperative societies near Mopti.

Training Outcomes & Feedback

Follow-up surveys were conducted in January 2021 with the participants of the first set of trainings to assess the effectiveness of the training and discover areas of improvement for future trainings. These interviews confirmed that the training program was effective in increasing the awareness and knowledge of clay pot coolers among the participants. Eighty-five percent of the respondents were introduced to the concept of evaporative cooling technology for the first time at the training. Prior to the training, 88% of respondents had been storing their vegetables in a basket or other basin, and half of those had been covering their storage container with a wet cloth.

Seventy-three percent of participants (which includes

50% of the farmers, 100% of the clay pot makers and sellers, and 92% of extension agents, vegetable sellers, farmers, and consumers that participated in the study) had assembled or purchased a clay pot cooler after the training, were still using them nine months later, and reported improved fruit and vegetable shelf life. All five participants that used a pot-in-pot configuration were either clay pot makers or clay pot sellers, with the remaining 19 participants (extension agents, vegetable sellers, and consumers) using the pot-in-plastic dish configuration. This illustrates the attractiveness of the clay pot-in-dish option, which can be assembled by users who may not have access to custom clay pots.

Furthermore, all 33 respondents to the survey, including the participants who did not decide to construct or buy clay pot coolers themselves, reported telling others in their community about the technology, who then began using clay pot coolers themselves. The main reason reported for not adopting the technology was a lack of materials or means (18% of respondents). The most common feedback with regards to the design reported by the participants was to increase the size of the clay pot to increase the storage capacity and accommodate more fruits and vegetables. Additionally, all five of the clay potters who attended a training began selling clay pots specifically as clay pot coolers after the training and reported sales ranging from 10 to over 50 clay pot coolers in the time since the training.

Djiguiba Boureima (left) and Kadidia Nienta (right) placing carrots, leafy greens, and sweet peppers into a clay pot cooler at the Nyeleni Cooperative Society in Mopti, Mali. Photo: Djiguiba Boureima

Training participants assembling a clay pot cooler at the Nyeleni Cooperative Society in Mopti, Mali.

Based on participant feedback, the program was improved by streamlining the training to a single half-day session, and a graphical *Guide to Assembling, Using, and Maintaining Clay Pot Coolers* was developed, which is available in English, French, Swahili, Spanish, Bambara, and Hindi, and was distributed to all new training participants. The second ToT took place in February 2021 with eight agricultural extension agents and a clay potter, followed by trainings of 289 people at 11 locations across Mopti in April 2021. The team is conducting additional monitoring and evaluation activities with the participants in the most recent trainings, and will resume conducting trainings in October 2021 after the rainy season ends in Mopti.

Conclusions & Next Steps

Because initial results indicate that using clay pot coolers can result in reduced food loss, time savings for women, and improved nutrition, and given the positive feedback on the dissemination program, we are looking to expand this program throughout Mali and beyond.

In addition to expanding the training program, the next phases of the project will have increased focus on quantifying the outcomes and impacts of the training program and clay pot cooler usage.

To further expand the geographical reach of the *Guide to Assembling, Using, and Maintaining Clay Pot Coolers*, it will be translated into Arabic and Gujarati, bringing the total to eight languages in which the guide is available.

Interested collaborators and supporters are welcome to contact MIT D-Lab's project lead, Eric Verploegen (ericv@mit.edu), for further information.

Kadidia Nienta conducting a clay pot cooler training at the Anya-Lobo Cooperative Society in Mopti, Mali. Photo: Djiguiba Boureima

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Amaranth stored in a clay pot-in-pot cooler at a training session that took place in 2021 at the Institut d'Economie Rurale research facility in Bamako, Mali. Photo: Alkassim Dicko.

Cover image: Djiguiba Boureima (left) and Kadidia Nienta (right) assembling a clay pot cooler in Samanko, Mali. Photo: Ba Germain Diarra.

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Suggested Citation

Shankar, N., Cissé, F., Ognakossan, K. E., Verploegen, E. (2021). Clay Pot Coolers - Preserving Fruits and Vegetables in Mali: Report 2016-2021. Copyright © Massachusetts Institute of Technology (Accessed on [insert date]).