Improving a solar dryer to reduce unnecessary food losses in Bhutan

Bhutan is currently struggling with unnecessary food losses due to the logistical challenges posed by its mountainous landscapes, thus, allowing the food to spoil before it reaches the people. To address this issue, the Swedish Research Council has funded a project, coordinated by Lund University, which aims to design a solar food dryer using only locally available material found in Bhutan, which aims to help preserve food and combat food losses. The dryer is going through an iterative process of tests and redesigns, and recently underwent rigorous field testing in Bhutan to reveal potential improvements.

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Nestled among towering peaks, Bhutan stands as the world's most mountainous country, renowned for its awe-inspiring landscapes. However, the rugged terrain poses unique logistical challenges, particularly when it comes to transportation of food. The repercussions of slow transportation times and inadequate food storage facilities are affecting farmers in the rural areas of Bhutan, leading to significant post-harvest losses. To combat this issue, the Swedish Research Council has funded a project called Solar Food: Reducing post-harvest losses through improved solar drying. The project aims to design a cost-effective solar-powered food dryer, improving food preservation techniques in the Himalayan region. The farmers in Bhutan are already very familiar with drying, as it is currently one of the most prevalent techniques for preserving food. But the way this is achieved is with a method called open-air drying, wherein the food is left in the open and exposed to direct sunlight to dry. Even if this both works and is basically free, it does come with some caveats. Firstly, the nutrient degradation caused by the harsh sunlight leads to lower quality food in a country which is already, to some extent, plagued by malnutrition. Secondly, it leaves food out in the open, unprotected from weather and animals, and if you have ever parked your car beneath a tree filled with birds, you know this might not be the most food-safe environment to leave produce.

The current design of the solar dryer is built using locally available material and consists of a heat exchanger, a solar absorber, heat storage and a drying chamber. It aims to address the challenges associated with open-air drying, while also drying the food faster. This will hopefully be accomplished through a clever implementation of a heat exchanger and heat storage. By incorporating a heat exchanger, the warm air leaving the dryer is used to heat the cold incoming air, thereby saving some of the collected solar energy. The idea of the heat storage is to prevent the dryer from becoming too warm during intense sunlight hours and instead use that stored heat after sunset, prolonging the effective use of the dryer while protecting the food.

The tests were performed by measuring temperature before and after each component in the dryer at different air flows. The plan was to find out what fan setting the dryer would perform optimally in, and to use the data to understand why. The tests revealed that the solar absorber, the black metal plate used to absorb sunlight to heat the air, performs optimally at medium to high air flows. However, the opposite was seen for the heat exchanger, where the higher flows meant more energy was lost due to poor utilization of it. But most importantly, the drying rate was shown to increase with higher air flows, regardless of the lower temperatures seen inside the dryer at the highest flows.

The conclusions drawn from all the tests proved to be different than expected. Firstly, the performance of the heat exchanger was so poor that its inclusion in the dryer, at least in its current design, should be questioned. Because it adds resistance to the airflow could its exclusion, in theory, be cheaper and more effective. Secondly, the dryer failed to reach sufficient temperatures to truly benefit from heat storage, while losing precious internal space to it. It is therefore believed that the best option would be to remove the storage and use the space for more food instead. Finally, the dryer did not manage to outperform open-air drying when it comes to drying rate.

Almost all results point to the same future improvement, a larger solar absorber. This enhancement would lead to an increase in internal temperature and, consequently, a higher drying rate. It would also increase the usage of both heat storage and heat exchanger, meaning these components might show vastly different results in a future design with a larger absorber. This means that there are two suggested paths for the project to move forward. One path is to increase the size of the absorber and keep the heat exchanger and heat storage, likely improving performance but at an increased cost. The other path is to keep the current design but remove the heat exchanger and heat storage while operating the dryer at the maximum fan setting. This approach will lower costs, simplify the design, and potentially offer a more cost-effective solution.

While the dryer, as it stands, may face challenges in competing with the open-air drying method, the insights gained from these tests hold the potential to drive redesigns that could aid farmers in Bhutan. These redesigns will hopefully mitigate food losses, enhance the quality of available food, and consequently contribute to economic gains for the farmers in the region.