Designing a novel indirect solar dryer and evaluating the results

Bhutan, like other Himalayan countries is facing challenges in preserving food due to the difficult terrain, causing it to spoil before reaching to the market. To tackle this problem, Lund University is leading a project funded by the Swedish Research Council. The project aims to create a solar food dryer using locally available materials in Bhutan. This dryer intends to preserve food, reducing losses. The innovative dryer will be tested and analyzed for functionality. Based on the results, it will be refined and field-tested to enhance cost-effectiveness and efficiency. Ultimately, the goal is to improve food safety and promote self-sufficiency in the region.

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The challenging landscape in Bhutan creates special problems, especially in transporting food. Slow transportation, lack of proper storage, and limited market access are causing significant losses for rural farmers in Bhutan after harvest. To address this problem, the Swedish Research Council is supporting a project named "Solar Food: Reducing post-harvest losses through improved solar drying." This project aims to create an affordable solar-powered food dryer, enhancing food preservation methods in the Himalayan region.

Drying food is a common practice in Bhutan, usually done by placing the food in the open under direct sunlight. While this method is cost-free, it has disadvantages. The harsh sunlight causes nutrient loss, resulting in lower-quality food, which is concerning in a country struggling with malnutrition. Additionally, leaving food exposed makes it vulnerable to damage from weather and animals, leading to spoilage or ruined dried products.

The current solar dryer design utilizes locally available materials and includes a thin heat exchanger made of low-density polyethylene, a large solar absorber, heat storage, and two drying chambers. Experiments were conducted in laboratory conditions using artificial solar lamps. The aim was to overcome challenges related to open-air drying and achieve faster food drying. This was attempted by incorporating a heat exchanger and heat storage, where warm air leaving the dryer heated the incoming cold air, saving collected solar energy. Additionally, tests involved replacing the internal fan with a bigger sized fan to enhance air circulation inside the dryer for quicker drying. To simulate real-life usage by farmers, an extra test was conducted by adding more trays to the existing set up of the dryer. The experiments involved measuring

temperatures before and after each component in the dryer at various air flows.

The results indicated that the solar absorber, a black metal plate used to capture sunlight for heating the air, worked best at high air flows. In contrast, the heat exchanger experienced higher energy loss at higher flows due to insufficient time to transfer heat through it.

Using a bigger fan between the two drying chambers in the dryer made fruits dry faster compared to using smaller fans. When extra trays were added, the overall drying rate decreased because there were more fruits to dry, taking more time. A notable finding was that fruits in different trays dried at different times inside the dryer. For example, apples placed near the hot air inlet from the absorber dried faster than those farther away. This difference became smaller when a larger internal fan was used.

The results from all the tests confirmed our expectations. Surprisingly, the plastic heat exchanger performed exceptionally well, which was unexpected given its low cost and easy availability. Including it in the dryer's current design should be beneficial. Additionally, using a larger fan inside the dryer speeds up the fruit drying process significantly. The dryer also outperforms open-air drying in terms of drying speed. However, it's important to note that these experiments were conducted indoors using artificial solar lamps, which might not accurately represent real-world conditions.

Even though there are uncertainties about how the dryer will perform in real-life situations, the knowledge gained from these tests has the potential to inspire improvements. These improvements could be beneficial for farmers in Bhutan, helping reduce food losses, improve food quality, and ultimately boost the farmers' economic prospects in the country.