Design and Construction of a Solar Dehydration System as a Technological Strategy for Food Sustainability in Difficult-to-Access Territories

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Abstract : The growing emphasis on sustainable food production and preservation has driven the development of innovative solutions to minimize postharvest losses and improve market access for small-scale farmers. This project focuses on designing, constructing, and selecting materials for solar dryers in certain regions of Colombia where inadequate infrastructure limits access to major commercial hubs. Postharvest losses pose a significant challenge, impacting food security and farmer income. Addressing these losses is crucial for enhancing the value of agricultural products and supporting local economies. A comprehensive survey of local farmers revealed substantial challenges, including limited market access, inefficient transportation, and significant postharvest losses. For crops such as coffee, bananas, and citrus fruits, losses range from 0% to 50%, driven by factors like labor shortages, adverse climatic conditions, and transportation difficulties. To address these issues, the project prioritized selecting effective materials for the solar dryer. Various materials, recovered acrylic, original acrylic, glass, and polystyrene, were tested for their performance. The tests showed that recovered acrylic and glass were most effective in increasing the temperature difference between the interior and the external environment. The solar dryer was designed using Fusion 360® software (Autodesk, USA) and adhered to architectural guidelines from Architectural Graphic Standards. It features up to sixteen aluminum trays, each with a maximum load capacity of 3.5 kg, arranged in two levels to optimize drying efficiency. The constructed dryer was then tested with two locally available plant materials: green plantains (Musa paradisiaca L.) and snack bananas (Musa AA Simonds). To monitor performance, Thermo hygrometers and an Arduino system recorded internal and external temperature and humidity at one-minute intervals. Despite challenges such as adverse weather conditions and delays in local government funding, the active involvement of local producers was a significant advantage, fostering ownership and understanding of the project. The solar dryer operated under conditions of 31°C dry bulb temperature (Tbs), 55% relative humidity, and 21°C wet bulb temperature (Tbh). The drying curves showed a consistent drying period with critical moisture content observed between 200 and 300 minutes, followed by a sharp decrease in moisture loss, reaching an equilibrium point after 3,400 minutes. Although the solar dryer requires more time and is highly dependent on atmospheric conditions, it can approach the efficiency of an electric dryer when properly optimized. The successful design and construction of solar dryer systems in difficult-to-access areas represent a significant advancement in agricultural sustainability and postharvest loss reduction. By choosing effective materials such as recovered acrylic and implementing a carefully planned design, the project provides a valuable tool for local farmers. The initiative not only improves the quality and marketability of agricultural products but also offers broader environmental benefits, such as reduced reliance on fossil fuels and decreased waste. Additionally, it supports economic growth by enhancing the value of crops and potentially increasing farmer income. The successful implementation and testing of the dryer, combined with the engagement of local stakeholders, highlight its potential for replication and positive impact in similar contexts.

Keywords : drying technology, postharvest loss reduction, solar dryers, sustainable agriculture
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