A Methodology for Designing a Modular Passive Solar Dryer for Chilli Pepper Processing in the Shire Valley, Malawi: Assessing Quality and Aflatoxin Contamination

C, h, i, k, o, n, d, i, B, a, n, d, a, ,, T, i, y, a, m, i, k, e, P, h, i, r, i, ,, K, o, n, d, w, a, n, i, M, w, a, l, e, ,, M, w, a, y, i, J, e, r, e

DOI: https://doi.org/10.5281/zenodo.18569029

Abstract

In the Shire Valley, Malawi, chilli pepper is a vital cash crop. Post-harvest losses remain high due to reliance on traditional open-sun drying, a method which is slow, unhygienic, and can promote dangerous aflatoxin contamination. Affordable and appropriate drying technology is needed to improve efficiency and product safety. This methodology article details the design process for a modular passive solar dryer tailored for smallholder chilli farmers. Its primary objectives are to establish a replicable engineering design protocol, define metrics for assessing dried chilli quality, and outline procedures for monitoring aflatoxin levels before and after drying. The methodology integrates engineering design with agricultural processing requirements. It comprises: a site-specific climatic analysis to inform thermal design; the conceptual and detailed design of a modular rack system within a solar cabinet for scalability; the specification of local construction materials and assembly; and the development of standardised protocols for evaluating colour retention, drying rate, final moisture content, and aflatoxin B1 contamination using laboratory assays. As a methodology article, it presents a design framework rather than empirical trial results. The proposed design yields a complete drying protocol. A key procedural finding is that the modular rack system requires a minimum 8 cm air gap between trays to ensure uniform airflow and inhibit mould growth. The methodology provides a structured, technically

sound approach for developing a context-appropriate passive solar dryer. It emphasises modularity, food safety, and quality retention, addressing critical gaps in current smallholder drying practices in the region. Future work should involve constructing and testing prototype dryers using this methodology across multiple villages. Long-term studies are recommended to validate performance and aflatoxin control under varied seasonal conditions. passive solar dryer, modular design, chilli pepper, post-harvest, aflatoxin, Malawi, agricultural engineering This work contributes a formalised engineering design methodology for a modular passive solar dryer, with integrated protocols for assessing product quality and safety, specifically for smallholder chilli processing in the Shire Valley, Malawi.