Sustainable Improvements for Guatemalan Cardamom Spice Dryers

Abstract

Imagine that a simple, inexpensive piece of sheet metal measuring two square feet is the key to preserving 1,500 hectares of Guatemalan forest per year. While the solution was simple, the process was not. The team was imminently aware from the onset that engaging all relevant stakeholders and soliciting both Guatemalan and American expertise from a broad range of disciplines was indispensable.

The cardamom trade is an economic lifeline for the country, as Guatemala produces 80% of the world's cardamom trade with an annual yield valued at an impressive $580M. Unlike many export commodities which are predominately in the hands of large multinational corporations, 300,000 indigenous farmers produce almost 70% of Guatemala's cardamom exports on small plots of 10 acres or less. Unfortunately, most cardamom is dried in inefficient wood-burning dryers where only 30% of the heat produced actually reaches the cardamom. Annual consumption from these driers totals 720,000 m^3 of firewood and 27 million liters of diesel, exacerbating the crises of Guatemalan deforestation and global climate change.

A Guatemalan agricultural NGO had initially planned to replace all 6,000 of the traditional inefficient dryers in Guatemala with efficient modern machinery. The magnitude of this task motivated them to concurrently consider small-scale, low-cost improvements to existing dryers. They approached an engineering NGO and provided a clear destination– improved efficiency– but no road map.

The team took on the challenge of creating that road map. The team of primarily mechanical engineering majors began by examining the mechanics of cardamom dryers and discovered that the heat exchanger was the least efficient component of the dryer.

The team conducted an analysis of multiple alternative solutions, all while guided by the principles of appropriate technology, including economic feasibility. Economically feasible solutions can be funded, fabricated, and operated by the end user. When this is the case, the solution is also scalable. The team was ultimately successful.

They arrived at a low-cost metal attachment called a swirler which is inserted into the heat exchanger tubes. The swirler creates more turbulence in the air passing through the tubes, resulting in more uniform heating and warmer air reaching the moist cardamom pods. The total one-time cost per dryer is less than $2 and is made from sheet metal and a pair of tin snips and pliers.

After lab-testing the swirlers, the team conducted field-tests on dryers in Guatemala. The results were promising, and they returned to the U.S. to optimize the design. The second round of in-country testing revealed that the improved swirlers decreased wood consumption by 20% and total drying time by 14%, which in turn reduced total diesel consumption. Overall processing costs were reduced by 15%. Precursory estimates indicated the one-time $2 investment would yield $23 in savings per drying cycle. The solution was not just economically feasible– it would result in ongoing savings.

The team then developed multilingual, culturally relevant materials and videos which demonstrate the benefits of swirlers and provide fabrication and installation instructions. Trainers are travelling throughout Guatemala with a goal of implementing swirlers on 60 dryers and training the respective dryer operators by the end of 2021, with plans to then scale up and ultimately train the operators of all 6,000 dryers on swirler installation. This would lead to an estimated reduction in annual wood consumption by 144,000 m^3, protecting 1,500 hectares of forests per year. Annual diesel fuel consumption would also reduce by 3.8 million liters. This would yield a total reduction of 112 million kilograms of CO_2e.

Over the last three years, the students, faculty, professional engineer mentors, and stakeholders have spent 11,000+ hours in their university's lab and in-field in Guatemala for their preliminary assessment, design implementation, and impact analysis on the spice dryers. This propelled the students into contexts where they were grappling with the complexities of the world's pressing issues in a multi-cultural context, all while reaching a destination for which there was no existing road map. They utilized their classroom learning in this complex scenario to develop a solution which reduces deforestation and improves overall quality of life in rural Guatemalan communities.