Using Drying Beads to Reduce Food Loss

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Food Science in Action:

- ✓ Food / Agriculture Processing
- ✓ Food Quality
- ✓ Food Safety

Vegetable seeds stored in sealed jars with drying beads technology (Photo Courtesy of Dry Chain America)

Dry Chain America uses drying beads technology to help farmers effectively preserve their seeds for improved longevity and viability. Postharvest loss is a burden for all farmers. In many developing countries, this issue is exacerbated by the humidity of tropical climates as well as insufficient technological inputs. When grains are improperly dried and subsequently stored, it leads to mold growth which often turns harvests into waste. Dry Chain America established and introduced the "dry chain" concept to farmers so they can properly keep their seeds dry. These principles along with the novel drying beads technology are viable solutions for smallholder farmers against postharvest seed loss in tropical areas. They could also be adopted, from a food safety and sustainability point of view, to the processing of other agricultural crops.

Introduction

At the time crops are harvested, their water contents usually are high, and they are not suitable for storage. The moisture must be reduced to levels where mold, bacteria, and enzyme activities are suppressed. Our ancestors recognized the value of reducing water content and utilized sunlight to dry and preserve foods such as grains and legumes. As farming scale increased and populations grew, postharvest processing and handling have adopted technologies and become an industry.

In developed countries crops usually are heat processed after harvest. The moisture content of crops is monitored and controlled during storage and transportation. However, in developing countries postharvest handling is challenging due to a shortage of energy resources like electricity and transportation. Large scale processing is often not available or practical. Farmers continue to rely on nature (sunlight and wind) to dry crops.[1] Unfortunately, nature is unpredictable and bad weather during harvest seasons can ruin the entire harvest. Additionally, a humid climate is an obstacle for postharvest processing and limits the potential for farm growth because it provides favorable conditions for mold and sprouting which often cause crops to become inedible and wasted. Appropriate technologies that are feasible for developing regions are needed: small or medium scale, low energy, sustainable, effective, and affordable.

Technology Overview

The concept of "dry chain" was first described by Dr. Kent Bradford, distinguished professor at the University of California-Davis.[1] Dry chain operates on the mantra of "Make it Dry, Keep It Dry," utilizing an easy-to-follow decision chart for implementation (Figure 1). The decision chart allows farmers to answer a series of questions regarding their seeds or harvests to determine the proper drying solution needed.

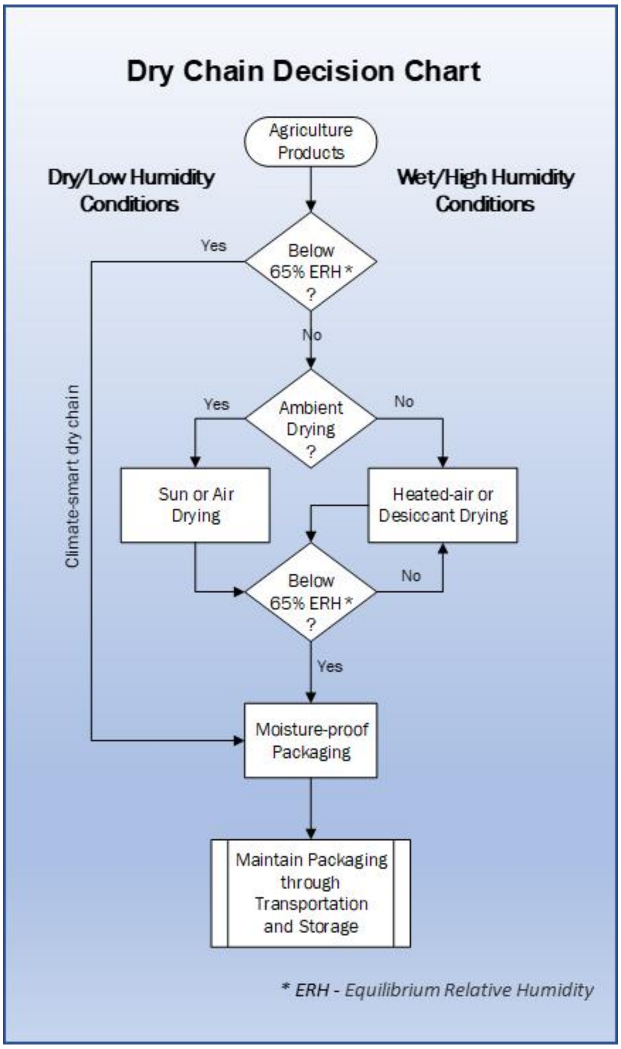

Figure 1. Dry Chain Decision Chart. Created by Dr. Kent Bradford. *(Trends in Food Science & Technology, 2018)*

It is worth noting, along with the decision chart, a low-cost indicator card called DryCard has been developed by The University of California, Davis and its Horticulture Innovation Lab (HortCRSP). DryCard mirrors the technology of pH strips but instead monitors relative humidity through the use of cobalt chloride strips. The card will display an estimate of the relative humidity within the sealed container in approximately 30–60 minutes; waiting for 2 hours will provide a more accurate measure. DryCard is a low-cost way compared to the standard in the U.S. and other developed nations of using expensive water activity monitors.[2]

Dry Chain America is the scaled commercial result of the dry chain research and drying desiccant beads. The company uses the climate-smart application of Drying Beads®, a patented, desiccant drying technology that may be used in tropical regions to dry seeds. The beads are more powerful than other desiccant materials such as silica gel.[3] They are made of crystalline zeolite and are rechargeable indefinitely by heating to remove the absorbed water. These modified ceramic beads can hold 20-30% of their weight in water, allowing for efficient drying at any temperature. They can be fully reactivated with no loss of holding capacity after each reactivation.[4] At this time, Drying Beads® are reactivated at high temperatures, 200ºC to 250ºC (392ºF to 482ºF), for 2 to 2.5 hours. New reactivation methods that would drastically reduce the reactivation time are also being tested. Drying Beads® in general are appropriate for drying seeds, grains, pulses, or horticultural products without heat, helping them to retain volatile compounds, flavor, color, and nutritional value.[5]

The Horticulture Innovation Lab at UC Davis has conducted projects funded by USAID's Feed the Future program applying the dry chain concept and drying beads technology. A partnership with Rhino Research, a seed technology group based in Thailand, allowed for further exploration of Drying Beads® for seeds in Nepal, Bangladesh, Kenya, Tanzania, Uganda, and Rwanda. The team of international researchers, led by Dr. Bradford, were able to demonstrate the effective use of the novel desiccant technology that improved seed quality and storage longevity for smallholder farmers in tropical climates.[2]

To keep the seeds or commodities at safe moisture levels, it is important to pack them in waterproof containers impermeable to moisture and that can also be used on the drying process. Drums designed to improve and support drying seeds or commodities.

The designed pore size specific for water molecules in the Drying Beads and very stable crystalline structure warrants a full reactivation and no loss of water-holding capacity over time.

Successes

Early pilot and commercialization studies of the technology relied on major Bangladeshi seed producers and agricultural processors as the technology adopters. It was to start with commercial channels that might eventually allow the technology to diffuse to smallholder farmers. In 2016-2017, the study estimated that the use of Drying Beads® in Bangladesh provided for the drying of 200 tons of vegetable seed, which ensured an estimated 100,000 farmers having better quality seeds.[2,6] Later the project was led by a local company, Metal Seed, which became the official Dry Chain distributor in Bangladesh.

> *"Our Dry Chain project in the highlands of Guatemala has been one of the most successful projects in my tenure at CIMMYT."*
>
> Denise Costich, PhD, Head, Maize Germplasm Collection CIMMYT- Mexico

The set-up of the Dry Chain distribution center is very effective. Well-trained and skilled personnel work at Dry Chain distribution centers are responsible for drying and storing the local farmers seeds/grains, reactivating the drying beads, and all the other necessary steps in the Dry Chain process. This assures that all of the proper measures are followed to prevent losses and contamination. It also eases the burden on distribution of the technologies and training farmers, and the potential costs incurred by farmers to purchase the drying beads themselves (although they could be charged a small sum by the facility to dry/store their products until planting).

The technology has shown to be beneficial in the preservation of textile materials as well, with projects in both Cambodia and Rwanda implemented to preserve clothing and textile materials. In Cambodia, where mold, mildew, and insect damage is common during prolonged storage, Drying Beads® allowed the textiles to be dried to proper conditions for storage without causing damage that heat drying would cause. The learnings from this project were then duplicated in Rwanda for similar preservation techniques. The projects were led by textile conservation specialist Julia Brennan of Caring for Textiles, supported in part by Rhino Research and Dry Chain America, and funded by the U.S. Ambassadors Fund for Cultural Preservations and other interested parties.[6]

It is important to work with regional stakeholders or collaborators from the beginning. Local stakeholders or research institutions are more instrumental in getting the projects off the ground. It would be a plus if governments are also involved and provide financial support or infrastructure assistance. From a cultural point of

Dr. Kent Bradford, right, discusses how to use drying beads to save horticultural seed with scientists and entrepreneurs at a meeting in Kenya held by the Horticulture Innovation Lab

view, connecting with locals can ease the implementation of Dry Chain technology in the community. Protocol development, tool kits for testing, and education all facilitated the adoption of Dry Chain and Drying Beads®. Eventually, the technology will be sustainable only when it is run by the people on their own.

When smallholder farmers initially implement Drying Beads® for commodity agricultural products, the costs are higher compared to traditional methods. However, due to the drying beads' reactivation properties (not losing water-holding capacity) and the increase in seed viability and reduction in postharvest losses, the higher costs are recouped over the course of several harvests.

Looking Ahead

Currently the applications for Drying Beads® are mostly in high value agriculture materials such as seeds and spices. However, it has the potential to be extended to commodity foods, grains, nuts, and vegetables. Here is a look at additional considerations for this technology to move forward:

1. The capacity of a Dry Chain distribution center should be designed and built with consideration of the local conditions, for example, logistically how the farmers can transport their goods to a local activation center. A scale too small or too large will make it impractical to operate economically.
2. It requires reactivation of the drying beads periodically using temperature-controlled ovens. Electricity or gas ovens could be expensive, therefore unsustainable, for the locals. In Guatemala and Mexico, local bakeries and bread ovens are used to reactivate the drying beads. There are also applications of microwaves to reactivate the drying beads. Solar and infrared technologies are being tested. Future work may incorporate other technology to make the energy consumption more environmentally-friendly as well as cost-effective.
3. Education is one of the key components when implementing Dry Chain technology. Farmers need to understand the dangers of improper drying and storage and the benefits of using new postharvest techniques, including the Dry Chain. It is not always easy to convince smallholder farmers. Many of them are not willing to take the risk of using a new postharvest

method and/or do not trust others to care for their seeds/commodities as their products are their lifeline and any loss could devastate their livelihood and family. Local stakeholders and value-chain actors should be involved at every step to facilitate the diffusion of knowledge and technologies.

Overall, the drying beads technology has many benefits in various areas. The ability of the technology to dry with minimal deleterious effects offers it an advantage for use in drying high value or critical materials (e.g., seed, spices, flowers, textiles, and even electronics). This lands well to a pricing structure that may allow for subsidizing based on the industry specific needs. This form of pricing exists today with materials that are used in the food and cosmetic industries and is a viable option for growth in the space of agricultural product drying.

References

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