Post Harvest Technology – yet another reason there are so many people

Contributed by Alice Friedemann
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Book review and commentary

Peter Golob, et. al. 2002. Crop Post-Harvest: Science and Technology. Volume 1: Principles and Practice. Volume 2: Durables. Volume 3: Perishables. Blackwell Science.

Introduction

It is amazing farmers can grow anything -- crops can be destroyed by drought, wildfire, flood, insects, birds, snails, rodents, fungi, bacteria, viruses, hail, frost, lack of vital nutrients, too much pesticide, and so on.

But that's only half the story -- once a crop has successfully been harvested, how do you keep it from being destroyed by all of the above plus spoilage and silo explosions? Civilization exists because our ancestors figured this out.

Before fossil fuels initiated the Industrial Revolution, 90% of the population was rural, unlike now, where over 80% of the population in the United States is urban. People preserved perishable food like meat, vegetables, and fruit by drying or with preservatives such as salt and alcohol.

Most people have gotten, and still get, the majority of their calories and nutrition from durables such as grains and beans.

Brian Fagan, in The Little Ice Age 1300-1850, describes how hard it was to store a harvest to last beyond one bad harvest and for the next planting, even if barns were stuffed to the eaves and local lords and religious foundations also stored crops.

During this period of climate change, crops failed often from blazing hot summers, excessive cold, or torrential rain. Two or more bad years in a row happened every ten years.

In the 20th century, post harvest food technology was developed and enormous granaries were built that can store grain for many years. These modern granaries keep rodents and other pests out. Durables are fumigated or sprayed with pesticides to kill insects at all stages of their life cycle.   Grain elevators keep durables cool and dry, vastly extending their storage life.

Post harvest technology preserves food after harvest and before delivery. Although transportation isn't part of the discussion, it's important to mention that the main reason famines stopped was the invention of the railroad. Areas with good crops could send their surplus to regions where crops had failed.

The length of time and amount of durables that can be stored with fossil-fuel built and controlled food storage technology is amazing. This technology has also made food safer to eat. Fossil fuels allow produce just harvested from the field to be cooled immediately, and kept cool throughout the supply chain, which makes it possible for us to enjoy fresh food year round -- often produce that's come thousands of miles before reaching our plates.

Golob et al's Crop Post-Harvest volumes 1-3 are heavy textbooks that provide an in-depth look at the continuing war to get perishables to market and to preserve durables. Both the old methods, still used in developing countries, and the amazing energy-intensive modern technology we've developed, are explained in great detail.

Humans are now using nearly all of the arable, ranch, and forested land on the planet, so preserving as much harvested food for as long as possible is our main hope of increasing food supplies in the future.

Why does good food go bad? How are durables such as grains and beans destroyed?

The main factors that limit the storage life of food are high temperatures and moisture -- in places that have both of these the length of time grain can be stored before it decays can be as short as a few months.

Temperature affects how quickly insects, mites, fungus, and mycotoxins develop and germination qualities are lost. The biological activity of insects, mites, fungi, and the grain itself doubles for every ten degrees centigrade rise in temperature. At low temperatures, insect breeding stops.

It's hard for insects and microorganisms to survive if there's no water, so low moisture is critical as well. This is why it's so hard to preserve fresh food for a long time -- fresh food has a very high water content, i.e. on average, the percent of water in apples is 84%, turnips 92%, pork 56%, Beef 58%, and fish 81% .

Damage and cleanliness

Produce that isn’t stored sterilely is bound to be degraded by some biological agent. Damaged produce provides a point of entry for secondary pests and saprobic fungi. Attack usually begins with one or a few species followed by the invasion of a broad range of non-specific microorganisms and secondary insect pests. Primary pests can also lead to quality losses since some insects feed on the germ region of seed, leading to a loss of nutrition or viability if planted.

Infection after harvest often occurs at the site of wounds from insect feeding or mechanical injury during the harvest. The main insect pests in stored food are Coleoptera (beetles) and Lepidoptera (moths), as well as diptera, psocoptera, and dictyoptera. There are also some bacterial infections of stored foods that can be serious, poisonous even, especially to those who are old, young or sick.

Rodents

There are over 200 species of rodents that damage crops while they’re growing, but rodents haven’t coevolved with grain storage long enough yet -- only 40 species of rodents prey on food stores. Rodents can eat 10% of their body weight every day. They reproduce quickly, so if even two of the opposite sex get in, it won’t be long before exponential growth begins. Rats live about a year, can get pregnant at 3 weeks with litters of four to eight, and reach adulthood in two to three months. You’ve got to go for 100% rat mortality or they’ll quickly come back. Rodents do even more damage by contamination with urine and feces than the food they eat.

Rodents can cause extensive damage to storage structures. They are almost impossible to keep out -- they can climb smooth surfaces, walk along wires, ropes, electric cables, etc. They’re also good at digging and tunneling, can gnaw through anything less than 5.5 on the Mohr hardness scale, i.e. lead, aluminum, tin, etc, so structures need to avoid edges rodents can get purchase on to gnaw. Some species of rats can jump five feet high, squeeze through 1/5th of an inch cracks, and swim long distances.

Birds and Insects

Birds not only eat grain directly from bins, but they’ll peck bags open. Twenty pigeons eat as much as a human does. Birds contaminate food and spread pathogens like salmonella and zoonoses.

Insects not only eat grain, but can affect the quality and taste of grain, affect the ability to make dough, and ruin the flavor. In the USA, some areas are more likely to succumb to insects than others. The highest risk area are the southernmost states, the lowest risk area are the states of South & North Dakota, Montana, Minnesota, Iowa, Wisconsin, Michigan, Oregon, Washington, Idaho, and Montana.

In developing countries, termites devour wood storage structures.

Fungi, mold, and microorganisms

Fungi flourish when moisture is over 22%. They can cause blemishes, blights, discoloration, and even wreak revenge in the next generation, when the fungi-damaged seed produces a diseased plant or reduced germination rates.

Molds can produce toxic myco and aflatoxins making them unsafe to eat and of poor quality.

If rodents, birds, insects, mites, fungi, and mold don’t harm the stored grain, then bacteria, viruses, yeasts, nematodes, anthracnose, blight, blotch, brown rot, canker, scab, dry rot, hyperplasia, hypertrophy, leaf spot, mildew, mold, mosaic virus, rust, smut, vascular disease, wet rot, soft rot, and toxins are potential destroyers.

And more…

In addition to all the pests and diseases, grain can suffer from mechanical damage at harvest, threshing, or any point thereafter -- while being hauled to market, and careless handling at the market.

Grain can be damaged if drying is done incorrectly, or through temperature extremes at any point. Moisture over 10-14% will lead to deterioration from fungi and biological degradation.

If grain is harvested too early, it will be green and therefore have high moisture content, causing it to rapidly deteriorate in storage. If harvesting is too late, the mature grain may be attacked by insects and microorganisms, or cracked from repeated rain and dry weather, making it easier for microorganisms to attack in storage.

Fresh produce

However hard it is to store durables like grain and beans, it’s much easier than fruits or vegetables, which must be delivered to the consumer quickly, often within days. The new, high-yield varieties of produce have higher nutrition, but they also have greater likelihood of spoilage in storage. Lack of plant nutrients in the soil affects the quality at harvest and the ability of the produce to store. Nitrogen may be good for growth, but it can lead to problems in some produce in storage.

For example, ideally lettuce is picked when the temperature is less than 60 degrees Fahrenheit and cooled within two hours. If kept cool, it won't spoil for nine and a half days. But if it's picked when it's over 75 degrees Fahrenheit and isn't cooled down until ten hours later, spoilage will begin in two and a half days.

Produce is pre-cooled by evaporative cooling, positive ventilation with ice banks, ice cooling, forced air cooling, hydro-cooling, and vacuum cooling.

Both durables (grains, legumes) and perishables are sprayed with chemicals to keep biota from attacking.

Fumigants can be essential to killing insects as well. Since Methyl Bromide causes ozone depletion, there's a race on to invent a new fumigant, but this isn't easy because there are so many essential properties. Fumigants must be a gas at room temperature, good at diffusing, kill all stages of pests, not be greatly heavier than air, and not leave harmful chemical residues. So other, costlier, methods of controlling insects are being tried, such as airtight storage, vacuums, and carbon dioxide atmospheres.

This is a very small subset of what's covered in these textbooks, which go in depth into the details of plant physiology, how to measure important storage parameters, detect pests, a long list of specific pests and the damage they do, how to build storage structures, manage pests, preserve food, the chemical structure of plants and oils, milling grains, trade and international agreements, applied research and dissemination, food systems, and much, much more.

Conclusion – Energy descent implications

If you've ever driven through the Midwest, you've seen enormous grain elevators from miles away.

These are built to protect against theft, rodents, birds, and insects. They're designed to keep the durables stored within dry and as cool as possible, by preventing cold humid air from getting into the grain at night and keeping the roof from getting so hot that condensation forms.

Climate change will make harvests far less assured in the future, with more years between successful harvests, as Brian Fagan describes in The Little Ice Age. Research into how to store food after harvesting for long periods is essential to prepare for the double whammy of extreme weather and declining energy [peak oil effects].

Long distance fresh produce will be the first to vanish from grocery store shelves as energy declines, but as Marion Nestle points out in What to Eat, the longer it takes food to reach market, the more nutrition is lost, so locally produced produce will be far more healthful.

So research into durable post-harvest storage is the most important to be funded. Currently, modern storage technology is very energy intensive, and favors large farms over small farms because:

Small farms are expensive to include in horizontal and vertical supply chains.
Small farms can't meet as stringent quantity and quality demands as large firms supplying food to markets.
Fruits and vegetables are hard for smaller or medium farms to deal with -- they need special packing and refrigeration equipment to cool down the produce, transport it. It's the large growers that can afford the computer-controlled deep irrigation systems, intense fertilizers and pesticides, and sophisticated packing plants to keep produce cool throughout the entire supply chain.
Small and medium farms don't have the money to keep up with the latest research on hygiene, health, aesthetics, development, labor costs, and marketing.
The cost to build and operate high-tech storage structures is huge.

Because agriculture, infrastructure, and western civilization are so dependent on fossil fuels, many writers have concluded the best way to lower suffering as energy declines, and to make as orderly and peaceful a transition as possible, is for millions of families to go back to the land. Clearly most families would prefer to be independent small farmers on their own land than poorly paid seasonal workers (see my “Peak Soil” -- link below -- and Richard Heinberg’s “Fifty Million Farmers” for details).

I hope, but doubt, there is funding for engineers and scientists to figure out the best ways to adapt existing infrastructure each step downward on the energy curve. In the case of post-harvest technology, one puzzle that needs to be solved is how to continue using the enormous durable storage facilities we’ve built. If long-term it’s impossible to load half-mile-long 120-foot high grain elevators without fossil-fuel driven energy, then let’s start building smaller grain elevators and other post-harvest storage technology while the energy to do so still exists.

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