White Paper

Produce Shelf Life:
Issues and Extension Methods From Harvest to Retailer

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Produce is a highly perishable commodity, making shelf life a race against the clock for growers, processors, and retailers. With national averages of produce shrinkage at 6%, according to the Produce Marketing Association, shelf life costs US retailers in excess of $2.1 billion per year. This paper will review factors that shorten and extend shelf life, and multiple methods to extend and measure produce shelf life as it pertains to produce processed from harvest to delivery to the retail facility.

What is Shelf Life

Shelf life is the period of time a food has before it is considered unsuitable for consumption or sale. The shelf life of fruits and vegetables can vary considerably depending on multiple factors. Post harvest shelf life of produce revolves around the basic fact that fresh fruits and vegetables continue to function like living organisms, even after they are harvested. Freshly harvested produce utilizes stored energy and oxygen to remain alive, a process called respiration. The faster the produce uses up its stored energy, the shorter the shelf life. The faster a product respires, the faster it will decay. Let's take a look at why shelf life is important and to whom.

Shelf Life Importance

According to the U.S. Environmental Protection Agency (EPA) the U.S. generates more than 34 million tons of food waste each year costing around $1 billion every year just to dispose of all its food waste. A University of Arizona study further claims that U.S. restaurants, convenience stores and supermarkets throw out 27 million tons of food every year, which they calculate represents $30 billion. This waste has a massive impact financially and environmentally on individuals and businesses alike. Although shelf life is not the direct cause of these substantial losses, it contributes significantly, affecting growers, processors, retailers, and ultimately, the consumer's bottom line. Financial loss coupled with today's longer transport times is every food handling institution's motivation for considering new technologies which extend shelf life

Factors that Shorten Produce Shelf Life

From the moment produce is harvested, the clock starts ticking and decay begins. The main factors that affect shelf life of produce include improper handling, inadequate humidity, temperature abuse and ethylene exposure. One UC Davis study concluded that a peach, with all four controls minimized, can last approximately 28 days. If that same product is subjected to storage at 43.2°F rather than the optimum 32°F, its shelf life is decreased by 50% (figure 1). Subsequently, if you add ethylene exposure, inadequate humidity, and improper handling, a peach may only last between 1 to 2 days. Solutions that provide tools and data to accurately control, monitor, and document these factors during storage and transport can effectively address these issues.

Handling

- If produce is improperly handled during harvest, resulting in damage or bruising, it will expend more energy faster than undamaged produce, reducing its shelf life. Additionally, if harvesting conditions are not sanitary, bacteria have the chance to thrive, as it feeds on stored energy. The results is more rapid decay and spoilage. Improper handling practices increase water loss and respiration and provide avenues for bacteria or mold to take root. Produce that is bruised or damaged mechanically or by human handling is more prone to decay. The National Center for Appropriate Technology (NACT) documentation states that heavily bruised prunes were found

to develop 25% more decay than unharmed prunes, which developed only 1.3% decay in storage. Examples of Improper post-harvest handling factors that can affect shelf life include:

- Washing produce with contaminated water
- Transporting produce in contaminated boxes
- Vehicle vibration, causing produce damage.

Additionally, damage to produce due to improper handling causes the produce to release large amounts of ethylene gas, which hastens decay in surrounding healthy produce.

Temperature and Humidity

Temperature and humidity also play an important role in shelf life and are directly related to each other. As an example, if the temperature of a cold room is increased by only 2°F, the relative humidity drops approximately 7%, reducing produce shelf life by 50%. Leafy greens last four times longer when stored in a room with 95% relative humidity, than in a room with 80% relative humidity.

According to a publication from the University of California, produce respiration increases 200 to 400% for each increase of 18°F (10°C), up to temperatures of about 77°F to 86°F. Additionally, it is important for growers and shippers to note that a byproduct of respiration is heat. For example, a truck with an ambient temperature of 32 degrees may have produce registering 2 to 4 degrees higher. Therefore, monitoring the ambient temperature may not be sufficient. Optimal storage and transport of fruits and vegetables varies by product, with optimal temperatures ranging from anywhere between 32°F with 90 to 95 percent relative humidity for strawberries, to 55°F – 59°F with 85 to 90 percent relative humidity for grapefruit. Using methods to monitor and analyze both ambient and product temperature and humidity during their processes allows handlers to better manage shelf life.

Ethylene

Ethylene is a hormone produced by plants and released as a colorless, odorless gas which the plants use to regulate their own growth, flowering, ripening, and aging. Injury and damage to plant cells, plus the natural process of maturation causes plants to increase ethylene production. It is an increasingly damaging cycle since the presence of more ethylene means hastening decay.

Ethylene increases cellular respiration, which in turn increases metabolic rate. After produce has been harvested, this increase in respiration will shorten shelf life.

Ethylene also causes plant cells to lose water, leading to dehydration, drying, and shriveling. It reduces many beneficial nutrients, such as Vitamin C, and leads to loss of leaves and flowers on the plant, yellowing and spotting of leaves and fruit skins, and sprouting (such as in onions, for example). Ethylene also changes the taste and aroma of fruits and vegetables.

One of the most damaging effects of ethylene gas is that it stimulates plant cells to increase their ethylene production, which accelerates all of the adverse effects associated with ripening, maturing, and decaying, and thus shortening the window of time for shipping, storage, and sale. Pallets of produce experiencing any extended period of shipment may arrive with damaged, unsellable product. This is a growing concern for food handlers needing to remain competitive as the food distribution chain lengthens and the costs of spoilage rise. Unique shelf life solutions using innovative packaging alternatives can slow the effects of ethylene on perishable commodities.

Factors that Extendend Shelf Life

Proper handling methods, careful monitoring and control of temperature and humidity, and use of shelf life extension packaging methods are key factors that contribute to extending the shelf life of produce.

Proper Handling

Harvesting produce at the proper time is extremely important in maximizing produce shelf life. According to the National Center for Appropriate Technology (NACT), produce harvested at its peak lasts significantly longer than produce harvested too soon or too late. Once produce is harvested, it is important to handle it as carefully as possible to avoid bruising or damage. This ensures that the produce arrives with a good appearance and free of decay. Processes that will avoid damaging produce and extend shelf life include proper training for labor, limited handling, packing in the field if possible, avoiding high drops into containers, padding cartons & containers, and not overloading or overfilling containers.

Lower Temperature And Higher Humidity

Preserving food using reduced temperatures has been utilized for over 100 years. Storing produce in cold temperatures with appropriate relative humidity levels protects fruits and vegetables from decay and bacteria. This extends the shelf life, which in turn extends the product's selling period. Transporting and storing produce at low temperatures slows the aging and respiration process of produce, as well as minimizing moisture loss. Additionally, the lower temperature minimizes the chances of produce being affected by bacteria, yeast, and molds. Today, there are many cost-effective ways to monitor temperature and humidity. The most effective solutions utilize tools and data management methods that allow for fast and accurate access to the data produce handlers need to make important decisions quickly.

When shipping and storing produce, it is important to maintain a constant temperature. Alternating cold and warm temperatures may increase the chances of decay because moisture is accumulated on the food's surfaces. Refrigerated rooms and transport vehicles must have adequate air flow and insulation to assist in maintaining temperatures. Modern day solutions provide cost effective and efficient systems which can monitor temperatures and alert produce handlers of excursions.

Not only is proper temperature important, there is also the need for relatively high humidity when storing or transporting produce. Produce is made up of significant quantities of water. Water content is affected by temperature, humidity, and air flow, and translates to freshness. Water loss, therefore, is an important factor in shelf life reduction. To maintain water, most produce must be stored or transported within a high relative humidity range. Since refrigeration removes moisture, maintaining the right humidity level can be problematic. Growers can employ various tactics to combat this issue, including using humidification devices, blowing air across pails of water, or wetting floors.

Limiting Ethylene Explosure

Temperature, humidity, and handling factors have long been known to affect produce shelf life. Ethylene, a relatively newly discovered factor in produce ripening, according to industry research, was first seriously studied in the 1930s. Longer ethylene exposure is the result of greater average shipping & travel times, from grower to consumer. Lengthier supply chains caused by an increase in imports and exports, the transition to fewer and larger suppliers, and the proliferation of regional distribution centers are all contributors. Combining cost-effective temperature monitoring with efficient ethylene control packaging can protect produce and extend shelf life.

New packaging strategies have been developed to address the challenge of limiting ethylene exposure during transport. Modified Atmosphere Packaging, or MAP as it is commonly known, is a technology that attempts to manipulate the atmosphere surrounding the produce in such a way to reduce or eliminate its exposure to ethylene.

Tools to Measure and Extend Shelf Life

Temperature and Humidity Tools

There are a variety of tools to monitor ambient and food temperatures and to monitor produce shelf life. These include thermometers, thermo-hygrometers, data loggers, wireless facility temperature monitoring systems, and devices to measure produce firmness, and sugar content.

- **FlashCheck Jumbo Display Digital Probe Thermometers** are ideal for measuring temperature at any stage of food handling. The thin needle tip probe has an extremely fast response time for taking internal pulp temperatures.
- **Non-contact infrared thermometers such as DeltaTrak's ThermoTrace** can quickly and accurately record produce surface temperatures. It is an ideal screening tool for incoming deliveries. Food products can be quickly inspected without damaging packaging or contamination since no probes are used.
- **Thermo-hygrometers** are useful for monitoring environmental conditions such as storage areas, greenhouses, and transportation units.
  DeltaTrak's Digital Thermo-Hygrometer displays both temperature and humidity and can be used with either internal or external temperature sensors.
- **Data loggers** are used in transit to monitor and record the temperature inside delivery vehicles. These devices provide an excellent history of the food's quality during transport.
  DeltaTrak's Real-Time Loggers provide precise, up-to-the-minute temperature monitoring for both in transit or storage use.
- **Facility monitoring, recording and alarm systems, such as DeltaTrak's FlashLink RF Wireless System**, can simultaneously track temperature and humidity around the clock, in multiple locations within a food processing environment. It indicates temperature changes that could be a result of equipment malfunction, and can be programmed to notify personnel when out-of-range conditions occur.
- **The DeltaTrak Penetrometer™** is an instrumental gauge that uses puncture pressure to determine the firmness of produce. The meter provides a quick easy-to-use method of determining the ripeness or maturity of produce.
- **The DeltaTrak Brix Meter** is a precise optical instrument that measures the sugar content of foods by using a sample of liquid from juices, soft drinks, canned foods, honeys, concentrates or juice from fruit or vegetables. The instrument represents readings relative to the Brix scale and is the primary unit of measure corresponding to the percent of sugar in a water solution. This device can be used to verify ripeness of fruit and/or the sugar concentration of any liquid.

Packaging Tools

There are different types of modified atmosphere. One method call¬s for injecting oxygen, carbon dioxide, and nitrogen into pallet covers or containers to modify the air surrounding the fruits and vegetables. This gas mixture or gas flushed type of system requires that the air surrounding the product is removed and the desired gas mixture is then inserted. The exact concentration percentage of oxygen, carbon dioxide, and nitrogen used is dependent on the type of food or produce being transported. The mixture is dependent on the product, packaging material, and storage temperature. The gas must be inserted into an airtight enclosure. These systems are complex, require significant added costs for the gas, and are labor intensive. Additionally, using this method on a pallet is only effective if the seal remains intact, rendering it ineffective for multiple delivery situations.

An alternate and less expensive method incorporates additives inserted directly into plastic films used for covering pallets or lining boxes of produce. PrimePro EAP® or Ethylene Adsorption Packaging is a new technology that falls into this category of modified atmosphere packaging methods.

- **PrimePro EAP®** pallet covers, carton containers and sheets are plastic polyethylene products containing a proprietary additive that removes ethylene from the air surrounding the fresh produce to slow down the process of ripening and decay. The products are made of a porous, breathable plastic that allows the proper exchange of gases through the packaging. This also prevents the growth of anaerobic bacteria on fruits and vegetables. Using this product in concert with ethylene removal and low temperatures significantly extends shelf life.
- **DeltaTrak's Air Repair Ethylene Absorber** products can dramatically reduce harmful levels of ethylene gas. They are composed of high efficiency, activated aluminum beads impregnated with potassium permanganate. The beads large surface area allows for maximum absorption capability. Loose weave packaging material ensures optimum airflow and oxidation of ethylene and other contaminant gases.

Conclusion

Produce shelf life has become increasingly difficult to monitor and control with today's longer supply chains. Temperature and humidity monitoring, as well as ethylene packaging tools have improved significantly in the past few years to aid processors in managing shelf life. Proper shelf life control holds tremendous financial benefits for produce handlers, and is the key to helping them remain competitive.

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