WHITE PAPER

Temperature Management and the Cold Supply Chain

Improving Quality, Shelf-life and Revenues with Pallet-level Monitoring of Fresh Produce

Introduction

Cold chain optimization for perishable foods is becoming increasingly important. According to the Natural Resources Defense Council, 40% of our food supply is wasted.[1] As their recently updated wasted report states, it's as if we leave the store with five bags of groceries then drop two of the bags in the parking lot and leave them. A lot of this waste is product with 33 percent of wasted food made up of fruits and vegetables.[1] The NRDC says waste totals $218 billion per year – that's 1.3% of the US GDP!

Another study done by the University of Florida Food Distribution and Retailing Resource Center identified that *one-third of shipped produce is wasted annually*. Half of that waste is a result of temperature problems experienced between the grower and the retailer. Successfully reducing this shrink has a direct benefit to the bottom line, totaling billions of dollars in recovered product. The trick is to *reduce* the shrink, not repurpose it or redirect it. We need to prevent it in the first place and pallet-level temperature monitoring solutions can make that happen.

Proper temperature monitoring and management throughout the cold chain is no longer a luxury but a necessity. Even relatively small variations in temperature can significantly impact the shelf life of fresh produce – and its value. Certain types of produce are more susceptible than others. Berries, cherries and mushrooms, for example, are extremely temperature sensitive. In the example illustrated below produced by the University of Florida, strawberries should be shipped at a consistent temperature of 34° Fahrenheit. A temperature drop of 2° will freeze and destroy the berries resulting in a complete loss of product. Shipping at an average temperature of just 42° (an increase of only 8°), shaves seven days off the shelf life, significantly impacting quality and potential revenues. Temperature monitoring throughout the cold chain − and providing the ability to act on changes in temperature in real-time − enables documented delivery quality and increased customer satisfaction.

Cold Chain: Strawberries	
Transport time to a distribution center	2.5 days
If maintained at a consistent 34°	10 day shelf life
↓ If 2°	freeze damage, complete loss
↑ If 4°	Lose about *3 days* of shelf life
↑ If 8°	lose about *7 days* of shelf life

The path between harvest and retailer for perishable produce involves many steps and handoffs. To maximize quality, value and shelf life, it's essential that temperature is monitored and managed throughout the cold chain.

Cold Chain Handoffs:

- Field to warehouse/packer – via truck
- Warehouse to distributor – via truck, plane, train
- Distributor to wholesaler – via truck, plane, train
- Wholesaler to retailer – via truck
- Retail loading dock to shelf

At each point along the way, there's potential for trouble. Produce could wait in the field or for precool, sit in the sun on a loading dock, or be stored in a truck with broken or uneven refrigeration. Beyond freshness and quality, each handoff also creates the opportunity to break the chain of responsibility. Without pallet-level temperature monitoring and logging, the warehouse can claim that the produce was fine when it left, for example, leaving the distributor wondering about the quality and remaining shelf life. Ultimately, the retail grocer is left making a determination on the quality and can accept or reject a shipment – or re-estimate its value – with limited or inaccurate information. Visual inspection or snapshot data about the product's temperature at a specific point in time isn't adequate to gauge remaining freshness and shelf life and the result is increased waste and lost profits for retailers.

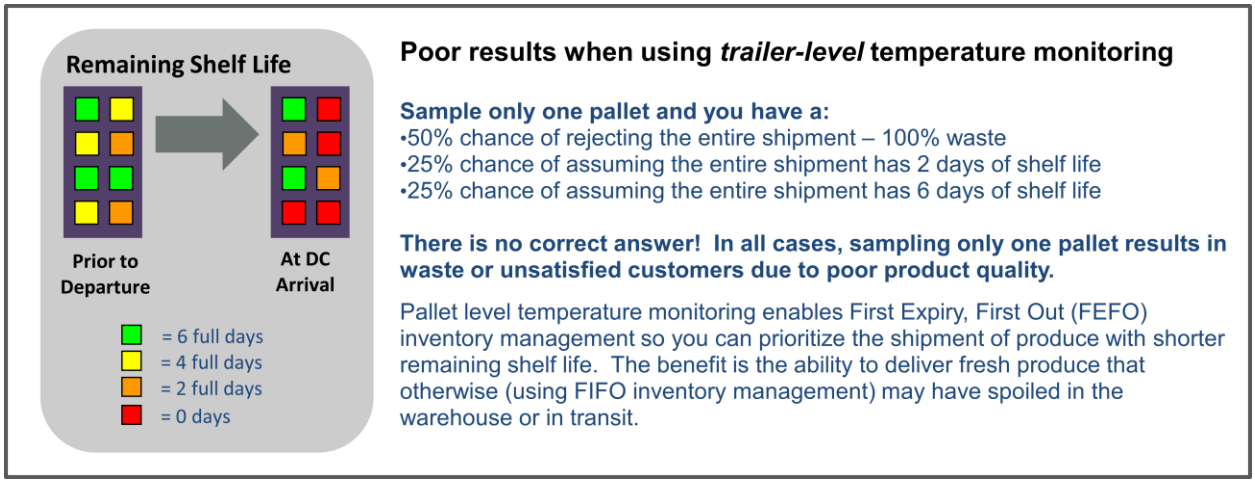
The Need for Pallet Level Monitoring

Well over a billion pallets of produce are shipped annually to retail grocers in North America and Europe – but how can you a billion pallets of produce cost-effectively? This problem isn't new to anyone but, without a viable method for addressing the previously cited multi-billion waste problem, the costs are passed through the cold chain.

The growers are often left holding the bag – a bag that is filled with the spoiled fruits and vegetables. The cold chain has tried to address this problem by implementing temperature monitoring solutions at various points along the way, such as environmental monitoring of the tractor trailer or the cold storage facility. However, this does not accurately track the condition of each pallet of produce, leading to inaccurate assumptions that group the condition of an entire shipment when it is known that the cooling (and quality) is not uniform. This leads to unnecessary waste and "finger pointing" in assessing liability.

For example, some members of the cold chain are implementing temperature monitoring solutions at the "truck level" by putting one or two temperature monitoring tags in the refrigerated trailer with the produce. While this provides some information on temperature

control, it's hardly adequate for monitoring the condition of each pallet of produce as temperatures within the trailers can vary significantly. Trailer-level monitoring doesn't account for the fact that the remaining shelf life of produce varies at the pallet level. What's needed is pallet-level temperature monitoring from harvest through to retail delivery.



The above diagram illuminates the benefits of pallet-level monitoring and how it enables a FEFO (First Expiry, First Out) model over the more traditional FIFO (First In, First Out) approach by factoring in the variation of pallet-level temperatures within a refrigerated trailer and its impact on the remaining shelf life of produce. FEFO-based inventory management means you ship out the product with the first expiry date first, regardless of when it was received in the warehouse.

The color codes indicate the remaining available shelf life of pallets in a trailer in a shipment from a grower to a retail distribution center. In the diagram on the left (prior to shipment), it indicates that two pallets (in orange) have only two remaining days of shelf life prior to departure, three (in yellow) have four days of remaining shelf life and three (in green) have six days of remaining shelf life. With this information, the distributor can chose to ship those with six days of shelf life (green) to more distant retailers and those with only two days of remaining shelf life to a location with rapid or same day consumption (such as a cafeteria). With pallet-level temperature monitoring, these FEFO-based decisions can be made at the warehouse − or other steps in the cold chain − at a pallet-by-pallet level and result in maximizing shelf life and improving cold chain yield.

Non-uniform ripening is a fact within the perishable cold chain. While there may be a number of contributing factors, a significant cause is due to temperature variations within the trailer. Note in the example above that the impact on shelf life is not uniform. That is, there is not necessarily a consistent ripening between each pallet. As such, a single "read" or assumption on the entire trailer shipment will be wrong for many of the individual pallets.

If the temperature is monitored only at the trailer level, the potential exists for poor decision making that can have very expensive consequences. As discussed in the example above, when the trailer arrives at the distribution center, only one pallet may be selected and sampled for quality. If a red pallet were chosen, the entire load may be rejected and wasted when, in fact, only half of the load should be wasted. Conversely, if a green pallet were chosen for the sample, the entire load may be accepted meaning that four pallets of poor quality produce will be delivered to stores or customers. In this example, in each case, trailer-level monitoring produces incorrect – and costly – results.

As a result, by implementing pallet-level temperature monitoring and FEFO inventory management, produce revenues can be improved by maximizing the available shelf life based on the *dynamic* state of the produce by knowing its temperature throughout the distribution process. What's important for maximizing the delivered value of the produce is knowing the current remaining shelf life (freshness metric) from the field to the retailer. This level of knowledge is what drives effective real-time decision making, proactive routing, shrink reduction and quality improvement.

There are additional costs that result from poor quality besides the cost of the wasted produce itself. Brand equity can suffer as consumers shy away from particular brands or grocers due to a poor experience. If a consumer favors a particular store for its produce but finds that the produce spoils the day after they purchase it, they may switch stores – especially given that many consumers choose a store based on the quality of produce. And, produce is a traffic builder, globally, we shop for fresh foods an average of 2.5 times per week.[2]

There's also a cost associated with being out-of-stock on a particular item. If a grocer rejects an entire shipment of produce because it has unknown or questionable quality, they miss the sales opportunity until replenishment, which may be days away, potentially driving customers to other stores – from whence they may not return.

From Grower to Grocer

Several companies are working to provide a more complete method of tracking the temperature of produce in-pallet throughout the cold chain. These companies are utilizing state-of-the-art Zest Fresh™ wireless solutions that enable them to place cost-effective and reusable temperature monitoring tags *within the packed produce at the pallet level* to monitor its temperature from field to store with little or no change to existing processes. The Zest Fresh tags can be automatically and wirelessly read while packed within the pallet of produce making this solution easy to implement. This means no additional labor cost for scanning codes.

Zest Fresh Temperature Monitoring Tags in pallets of bell peppers

On the island of Oahu, the Hawaii Department of Agriculture worked with a local produce provider to optimize the cold chain from the warehouse to the retailers. Hawaii is heavily dependent on agriculture – both locally grown as well as imported. However, due to the tropical Hawaiian climate, spoilage due to temperature exposure is a significant problem, especially when shipping produce from island to island, or receiving produce from the mainland or Asia. Once the produce leaves the producer's warehouse, it can be subject to damaging temperatures inside a truck or sitting on the hot tarmac at the airport waiting for the air carrier to load it and transport it. Temperatures inside the produce can quickly reach the ambient air temperature or higher – drastically reducing the shelf life.

Air Freight is a Critical Component of the Cold Chain in Hawaii

Zest Labs worked with the Hawaii Department of Agriculture and others to monitor and log the pallet-level temperature data from the warehouse, on board the trucks, at the airports and through to the distribution centers on other islands – providing accountability and control throughout the entire process.

Accountability and Quality Control

This project and others demonstrate the benefits of monitoring the temperature from grower to grocer. Temperature monitoring tags can be placed with the produce at the time of harvest and accessed throughout the distribution process providing invaluable temperature data. The grower, transporter and grocer can make more informed decisions and better manage their inventory to maximize the produce shelf life. They can also look at the historical temperature data to determine if systematic breaks in the cold chain exist and how best to correct them. This not only helps manage the quality and shelf life of the produce but also helps optimize the cold chain and drive down costs.

The Zest Fresh temperature tags also log waypoint data. Every time the tag is read, location information can be recorded to further enhance accountability. This data is extremely helpful in optimizing cold chain operations.

Making It All Work

Pallet-level temperature monitoring will drive improvement in the cold chain. Affordable, reusable temperature monitoring tags that can be read without unpacking the pallets or containers is what makes pallet-level monitoring possible. Because the tags can be read when placed within the produce on the pallets, no changes to produce handling are necessary. Because the tags feature on-board memory, they can store thousands of temperature data measurements – as well as waypoint and other data – that can quickly be accessed and used as the basis for real-time acceptance criteria or shipping prioritization based on FEFO inventory management.

The result is a system where decision making can be made on demand, in real-time, to maximize shelf life, improve quality and value and increase revenues.

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1. https://www.nrdc.org/sites/default/files/wasted-2017-report.pdf
2. http://www.nielsen.com/content/dam/corporate/mx/reports/2013/Nielsen%20Global%20Fresh%20Foods%20Report.pdf

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