KEY TECHNOLOGY
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White Paper

# Expanding Electronic Inspection Capabilities

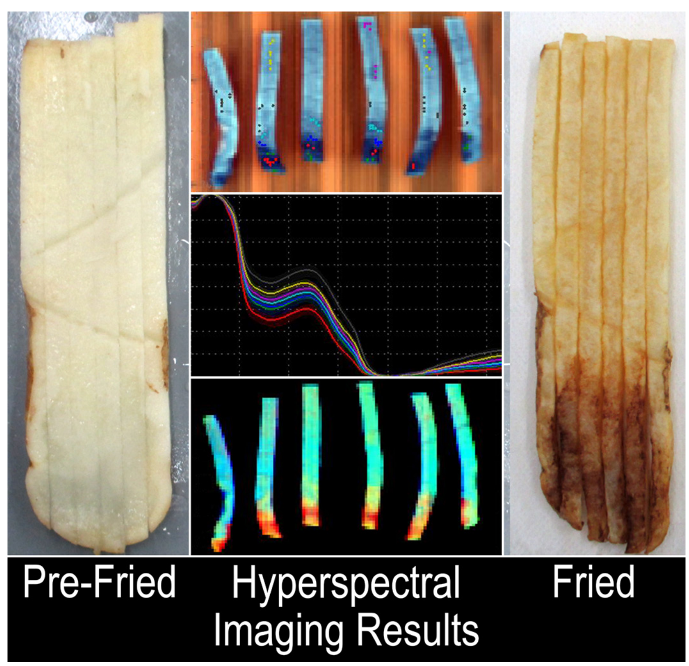
The fast pace of technology development is fueling the rapidly expanding capabilities of electronic inspection equipment to deliver new value to potato processors. In addition to enhancing the effectiveness of sorters to achieve better results, new technology is enabling completely new sorting decisions that hold tremendous potential to address many of today's product quality challenges.

In this article, I will highlight several leading-edge advancements on the horizon that promise to change the landscape of traditional optical sorting and usher in a new era of digital sorting with new sensors and greater software-driven intelligence. Forward-thinking potato processors that become the early adopters will be the first to transform industry threats like sugar ends and zebra chips into opportunities to pull ahead of the competition by leveraging new technology that optimizes product quality and maximizes yields in new ways.

## Sugar Ends and Zebra Chips

French fries and potato chips processed from sugar end potatoes exhibit undesirable dark brown areas after frying that are caused by the higher concentration of reducing sugars caramelizing. The anomaly is also referred to as "glassy end," "translucent end" and "jelly end." Much work has been done, and research continues, to pinpoint the causes of this physiological tuber problem so steps can be taken to manage those conditions and better control it. Largely weather-caused, other factors such as field selection, crop rotation, irrigation practices, tillage, fertilization, planting, harvesting and storage are under scrutiny.

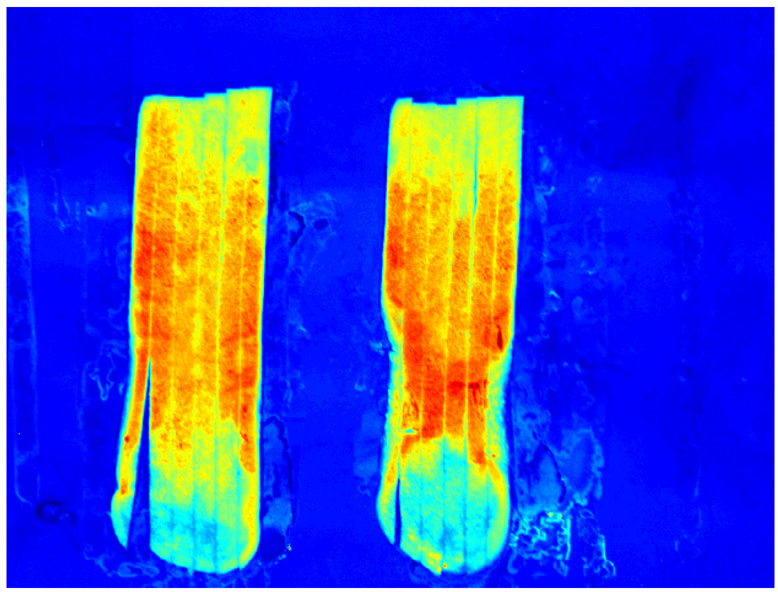
Since weather plays such a big part in causing sugar ends, with minimal aid from improved farming practices, potato processors will need to continue to manage often complex logistics regarding storage, crop shifting and blending and also remove/modify affected products to achieve their final product quality specifications. The challenge is that sugar ends are invisible to traditional cameras and lasers until after the product has been thoroughly fried.



Unlike sugar end potatoes, which are caused by environmental conditions, zebra chip is a disease caused by a pathogen. Like sugar ends, zebra chip is invisible to traditional optical sensors until the potato strip or chip is fully fried when stripes of sugars caramelize and dark lines develop, rendering these products unsalable.

Most optical sorters equipped with typical color cameras and/or lasers can easily identify the dark brown areas after the sugar end potatoes or zebra chips are fully fried. Therefore, potato chip processors can rely on a traditional sorter located after the fryer to remove these undesirable products prior to packaging. For potato strip processors that partially fry products, sugar ends and zebra chips are monitored along with other product quality attributes in today's current process that, most argue, does not leave one with high confidence, statistically-speaking. When found to be out of grade, there are decisions to be made, all of which negatively affect profitability, such as re-work or negotiating a relaxed specification (at a lower cost), which can also jeopardize the customer-supplier relationship. New sorter capabilities are needed to detect and remove sugar ends and zebra chips on potato strip production lines and before frying on potato chip lines.

New-generation sorters that feature multispectral and hyperspectral imaging systems show tremendous potential in detecting sugar ends and zebra chips prior to frying, as well as other invisible potato defects. When complemented by capable algorithm and software intelligence, this new kind of sensor essentially enables sorting on the chemical composition of the product.



Like traditional trichromatic cameras, hyperspectral cameras collect data from across the electromagnetic spectrum. Trichromatic cameras historically used on sorters divide light into three bands, which can include red, green and/or blue as well as infrared (IR) and ultraviolet (UV). By comparison, hyperspectral systems can divide light into hundreds of narrow bands over a continuous range that covers a vast portion of the electromagnetic spectrum that extends beyond the visible. Compared to the three data points collected by trichromatic cameras, hyperspectral cameras can collect hundreds of data points, which are combined to create a unique "fingerprint" for each object. The hyperspectral sorter then processes those fingerprints to intelligently remove visible and invisible defects and foreign material.

While sugar ends and zebra chips cannot reliably be detected using traditional trichromatic cameras or lasers prior to being fully fried, new digital sorters equipped with hyperspectral imaging systems promise to expand sorting capabilities and tackle these product quality challenges.

It's possible to incorporate hyperspectral imaging on freefall and belt sorters for inspecting frozen strips, wet strips and potato chips, and on whole potato sorters inspecting peeled or unpeeled tubers prior to cutting. There are significant operational advantages associated with locating these powerful detection capabilities upstream so the processor doesn't invest resources in processing defective product. Additionally, there is significant yield-improving potential that comes from marrying hyperspectral imaging technology with automatic defect removal (ADR) systems that actually cut the affected area from the strip, maximizing recovery. These digital sorters and ADR systems are being developed for the potato industry now.

### New Levels of Sorter Intelligence

While new sensing technologies are being introduced to expand sorting capabilities, new software and algorithms are also being developed to enable sorters to make new kinds of decisions.  Sort-to-Grade and Strip-Length-Control are two examples of software-driven advancements for potato strip processors, and real-time data fusion is a new advancement that could benefit any food processor.

Sort-to-Grade is a powerful new capability that enables select sorters or automatic defect removal (ADR) systems to control the quality of output to a defined grade. By evaluating potato strips with minor defects against the current grade count, the sorter can allow some of those strips with minor defects to pass and still maintain grade. Tests show that Sort-to-Grade can increase yields by one to three percent while assuring final product quality.

Most sorters make accept/reject decisions by comparing the size and color of each defect to predetermined criteria. Until now, those decisions have been made regardless of final in-the-bag quality results. Since final product specifications often allow a specific amount of minor and moderate defects, the operator has historically had to adjust the sorter's accept/reject thresholds subjectively in an effort to make grade given inevitable fluctuations in the quality of incoming product. This traditional "sieve" approach to sorting usually results in too many defects being ejected, along with the inadvertent ejection of good product, which translates into a significant yield loss. If incoming defects spike, the old "sieve" approach to sorting typically causes too few defects to be ejected and quality specifications are missed.

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Now, with Sort-to-Grade, accept/reject decisions consider the size and color of each defect and, most importantly, how potentially passing that particular defect will affect the overall final product quality in comparison to product specifications. Sort-to-Grade is a dynamic solution that allows a processor to establish its target grade, and then automatically adjusts the sorter to stay on grade as incoming product conditions change, without manual intervention. This new capability enables sorting systems to objectively sort defects by count in real-time with 100 percent inspection. Sorting foreign material (FM) remains unchanged, since every processor is looking to remove 100 percent of FM regardless of count.


Strip-Length-Control is a subset of Sort-to-Grade that focuses on strip length. It is also dynamic in that it automatically preserves the length profile of final product despite the length of incoming strips fluctuating as the sizes of whole potatoes vary. This new sorter capability allows potato strip processors to eliminate mechanical length grading methods and the product damage they can cause.

With either Sort-to-Grade or Strip-Length-Control capabilities enabled, the sorter can be programmed to send an out-of-grade alarm to notify operators to take corrective action when it isn't possible to maintain final product quality requirements given the quality of incoming product.

Real-time data fusion is a new software-driven advancement that is enabled by the newest and most powerful computing platforms found on select digital sorters because it requires so much bandwidth to manipulate this high volume of data. Unlike parallel processing on a traditional sorter or the limited data fusion capabilities that can be achieved with some newer sorters, real-time data fusion fully combines the data from multiple sensors into one algorithm to make accept/reject decisions. Fusing data from multiple sensors increases the contrast between various types of objects, which improves the accuracy of differentiating FM and defects from good product to enhance a sorter's ability to detect and remove objects such as glass, which have historically challenged traditional sorters. For potato strip and potato chip processors, real-time data fusion promises to improve product quality while increasing yields by reducing false rejects.

Technology is always advancing and that's good because its progress adds functionality and expands capabilities. However, the risk of obsolescence is a serious one and requires proper planning to minimize. Processors will want to work with suppliers that make upgradability a high priority and establish migration paths that enable existing customers to upgrade modules rather than forcing a redesign or replacement of the entire sorter. In addition to modular designs, features that often ease upgrades include FPGA (field-programmable gate arrays) chipset technology, which allows for simple future hardware upgrades without module replacement, and the use of connectivity standards such as Camera Link and Fire Wire, which simplify sensor module replacements. The goal is to select a supplier and a sorter that will help generate the maximum long-term return on any sorting investment.

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