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Revisiting Practical Considerations in the Application of Oxidation Reduction Potential (ORP) as a Water Quality Metric

Over the past two years, I have been providing talks in various workshops entitled *Dump Tanks and Other Scary Places.* In response to several recent industry meetings last month and a plethora of e-mails over the past few months, I thought it worthwhile to revisit and re-position our often cited perspective on redox potential as a standard and auditable metric for harvest and postharvest microbiological water quality management. ORP sensors measure the oxidizing or reducing potential of a solution.

The higher the ORP value, read in millivolts (mV), the greater the oxidizing action and the shorter the microbial kill time in water. In general, various market-access standards specify a redox potential critical limit of 650 millivolts (higher operating limits; often ~ 725 to 850mV) and a pH window of operation (6.5 to 7.5) to reduce the risk of cross-contamination within and among treated lots. The combined redox and pH metric are commonly referred to as an Oxidation-Reduction Potential (ORP) standard measured by in-line or handheld sensors. Technically, specifying a pH range is less critical and, when operating properly in our experience, the mV value is the sole determining criterion. Unfortunately, our extensive experience in evaluations of commercial wash water systems has demonstrated that this level of control and reliability of ORP measurements, against microbiological quality objectives, is often elusive in daily operations. Postharvest systems can be optimized to accommodate ORP as a single value control and operating standard in some but not all systems. In commercial settings, recirculated water with substantial, progressive accumulation of suspended solids and combined chlorine appear to be the most challenging to execute good process control. The result is in-line sensor saturation and diminished response time to correct for periodic deficiencies in dosing.

The current questions consider chlorine and hypochlorites in relation to an ORP standard. Therefore, this note will restrict comments to commonly used oxidizers. For brevity, operational challenges with ORP with treatments such as chlorine dioxide, ozone, and peroxyacetic acid are not discussed.

Plainly speaking, ORP values in wash systems bear no relationship to measured free chlorine (ppm) in common postharvest situations. If standards for quality or decay control require meeting a ppm limit, typically well beyond the linear scope of redox measurements, an ORP sensor is not the practical measurement and injection control system of choice.

In our studies conducted under laboratory conditions, and in some commercial packing facility wash lines, using chlorine-based systems, ORP has been found to be a functional and practical single-value measurement of disinfection. ORP can be a verifiable and successful method of assessing the antibacterial and antifungal status of the washout, flume, wash-line, or cooling water systems. Conversely, ORP measurements in surveys of recirculating commercial systems for Raw Agricultural Commodities (RAC) have not proven to provide a repeatable correlation to a target concentration of free chlorine. This is most apparent in water quality of high turbidity, high suspended solids, elevated conductivity from combined contributions of incoming product and non-product sources, and repeated injection of sodium hypochlorite during daily operations. However, we have had several opportunities to demonstrate that the ORP status of the water, over a broad pH range, correlates well with microbial lethality due to the oxidizing potential of the solution. Clearly, ORP sensors, like any equipment, need to be calibrated, maintained, and replaced as necessary to give accurate readings. ORP sensors, especially in-line probes, may be prone to oxidizer saturation or fouling and therefore give readings not reflective of the current water quality conditions within a system. Spot-checking with a calibrated hand-held ORP sensor at multiple locations often reveals a high variability in readings with “hot-spots” and locations well below the critical limit.

It is always advisable, if not essential, to have redundant systems that verify that the process is under control. A well-managed system includes periodic testing with hand-held ORP and pH sensors at multiple points and cross- checks with direct measurements of available free chlorine to make sure all measurements agree within a practical range. Verification with periodic microbiological testing under a range of operating conditions is highly desirable and informative.

Returning to the specific questions that have been raised, in my opinion and experience, setting an operational limit at 650mV ORP in any harvest or postharvest process water setting is highly likely to be inadequate in meeting current microbial reduction and prevention of cross-contamination potential expectations. A system at this redox potential would be anticipated to be functioning without necessary levels of hypochlorous acid for extended and untracked intervals.

Increasingly, some buyers and public health jurisdictions require a minimum free chlorine dose and a specified pH range as the necessary operating standard. **Acceptance of ORP standards is unlikely in the absence of detailed site and process-specific validation.** There is very good evidence that an ORP value of 700-725 mV is acceptable for source water treatment for general bacterial control. However, the prevention of cross-contamination on food contact surfaces associated with single pass sprays of raw product on conveyors or the potential for rapidly changing conditions in re-circulating dumps and flumes are likely best managed at higher ORP settings or directly measured free chlorine dose (ppm) and pH.