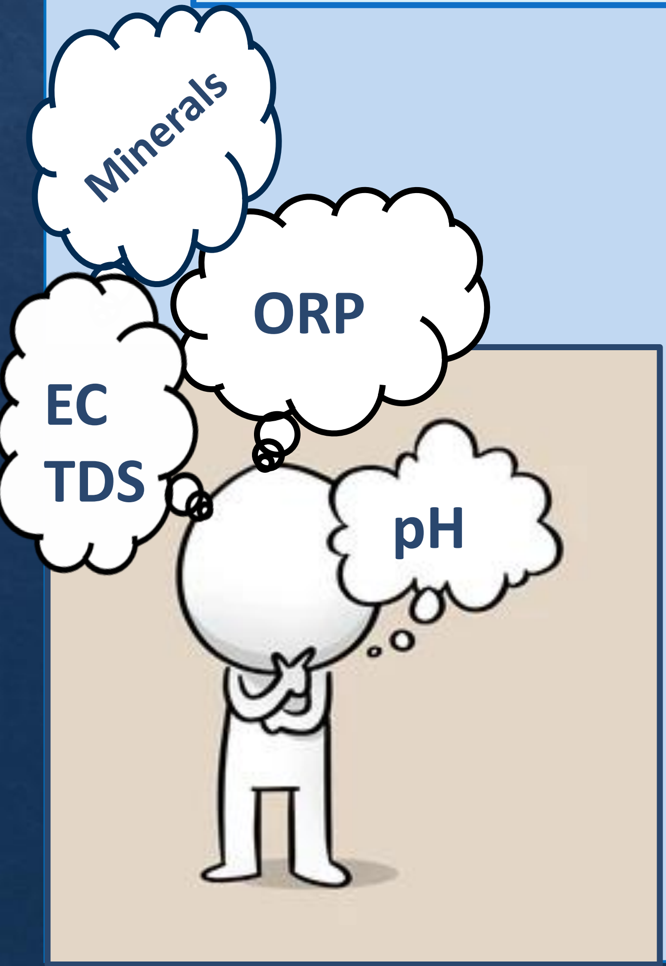
# Water parameters that can influence your sanitiser's efficacy




**Rudolph Strydom**
Postharvest Extension Officer (North)

CRW

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- Water sanitisers' main purpose is to sanitise the solution, not the fruit.

- **Broad-spectrum –** Unlike fungicides

- Spores washed off the fruit should be deactivated.
- Prevents the bath from being an inoculum source – Healthy fruit infected.

- **Fast acting/ short reaction time – Kills spores quickly.**
- Not protective like fungicides – No lasting residue.

- Can work in synergism with compatible fungicides – Reduce decay.

# What is used?

- Chlorine and peracetic acid-based sanitisers are most common.

- Other actives:
  - Clove oil (One product now registered as Act 36; A Fungicide)
  - Potassium sorbate
  - Chitosan
  - Stabilised glutaraldehyde

- Different modes of action, but all broad-spectrum.

- Effectivity, corrosivity, Phytotoxicity, Difficulty of management, etc.


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# What ensures that the full sanitation potential is reached?

- **Meticulous management:**
  - Concentration
  - Measure and monitor
  - Top-ups
  - Exposure time

- **Today's focus -** Water parameters that can influence success:
  - pH
  - ORP
  - EC and TDS
  - Minerals
  - Organic matter content

- **THEY CAN AND SHOULD BE MONITORED AND CONTROLLED**

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# Incoming water

- Water quality may impact sanitation potential before any sanitation occurs.
- For **optimal** functionality, the water should be:

  **clean, with a neutral pH, and without excessive salts or minerals**.

- Source of packhouse water (surface, ground, municipal)

  & the soil type of the area – Affects pH, EC, TDS, etc.

- Pre-treatment might be necessary before use.
  - Sanitation, filtration, and flocculation.

# Why is pH important?

## …for post-harvest chemical application


- Effectiveness of several chemicals is affected by the solution's pH

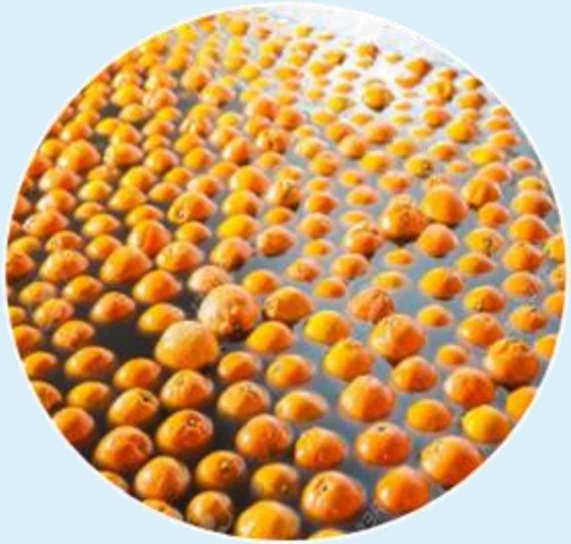
- Some chemicals **function optimally** within a specific **pH range**
- Chemical **formulation altered** outside this range

- Initial pH outside of the desired range
  - Measure and adjust

# Packhouse visit results

| PERCENTAGE OF PACKHOUSES THAT MANAGE THE PH OF THEIR SOLUTIONS INEFFECTIVELY | | | |
|---|---|---|---|
| pH | < 6.5 | 6.5 – 7.5 | > 7.5 |
| Chlorine solution | 10.9% | 37.5% | 51.5% |

# Chlorine-based sanitisers



- Chlorine most widely used wash water sanitiser in SA
- Disinfects water + deactivates fungal spores on fruit surfaces
- Prevents inoculum accumulation & cross-contamination

- Different formulations (most pH-sensitive), but calcium hypochlorite (cal-hypo, HTH) is recommended
- More available free-chlorine + less risk of chlorate formation (EU MRL < 0,05 ppm)
- Chlorine disinfection – determined by **pH**, **ORP**, and contact time

How does chlorine function?

and what does pH have to do with it 

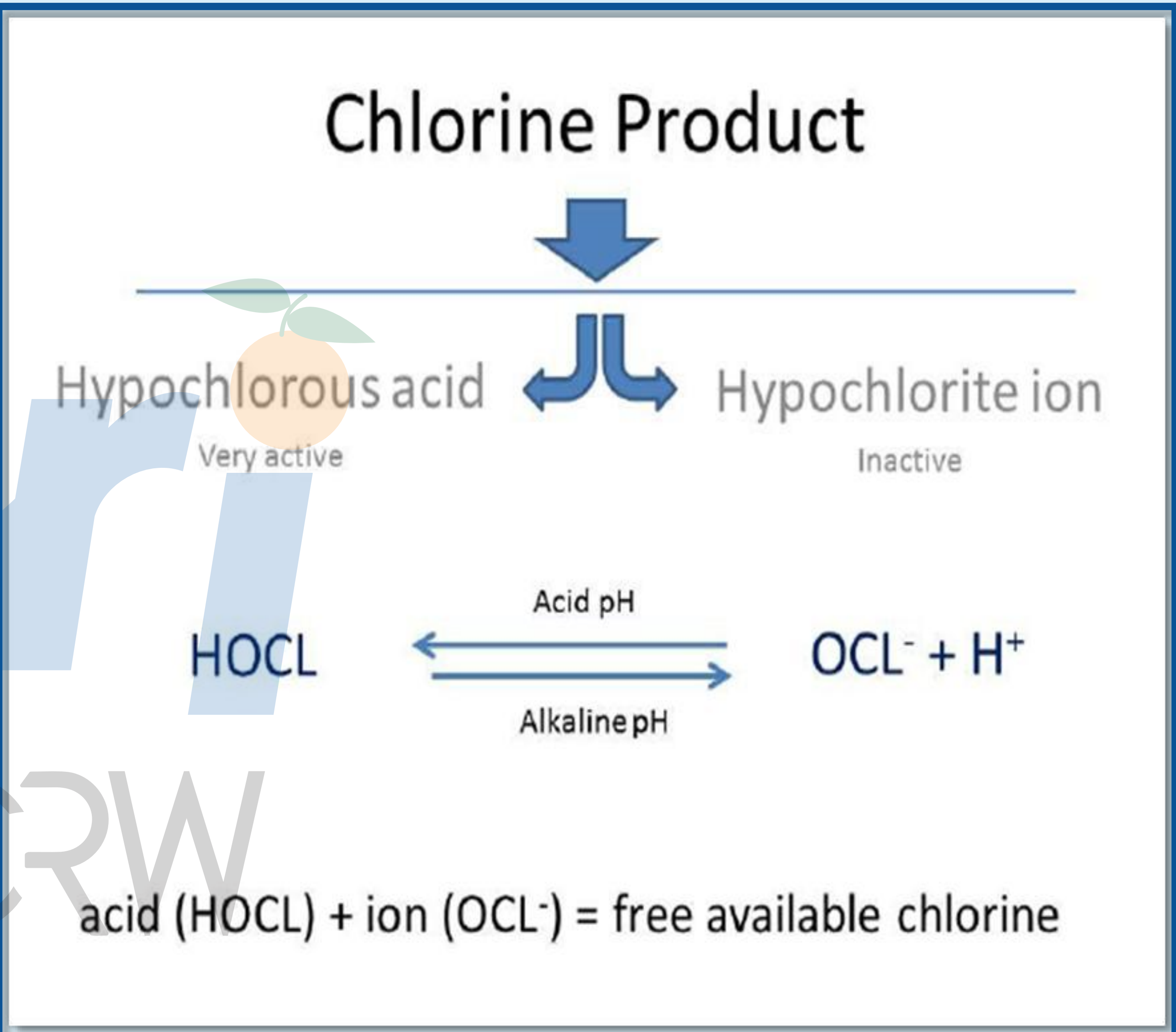
- Chlorine added to $H_2O$

= Breakdown/ dissociates

  - Hypochlorous acid (**HOCl**)
    *Strong oxidation potential*

  - Hypochlorite ions (**$OCl^-$**)
    *Weak oxidation potential*

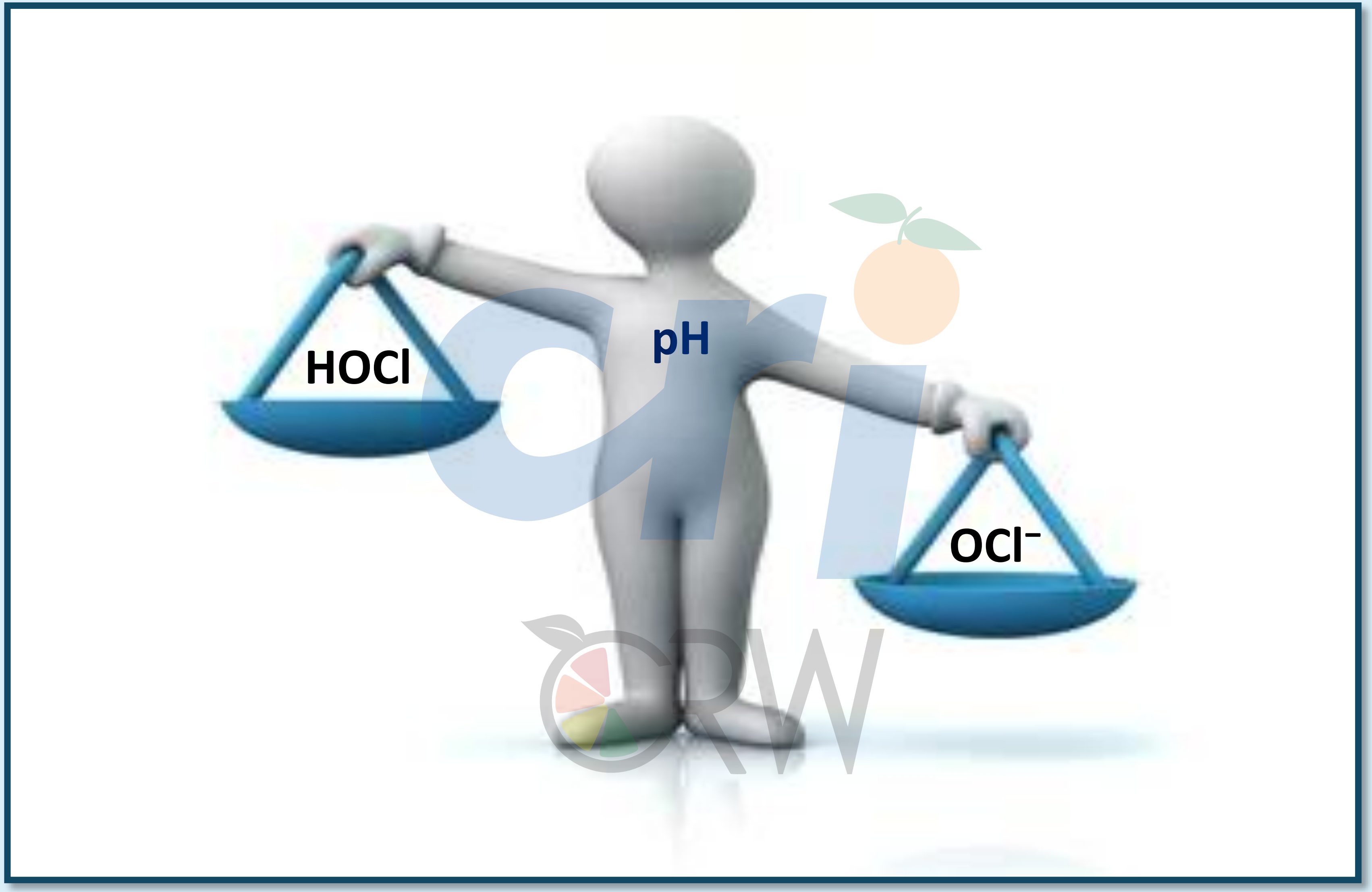
- **HOCl** is the **better sanitiser**
- **80 to 100x** more oxidation potential than $OCl^-$
- IMPROVED antimicrobial activity




**$Cl_2 + H_2O \rightarrow HOCL + HCL$**

**Chlorine + Water → Hypochlorous Acid + Hydrochloric acid**

**$HOCL \rightarrow H^+ + OCL^-$**


pH
HOCl
OCl⁻

- **pH 7.5** ⟶ HOCl = $OCl^-$

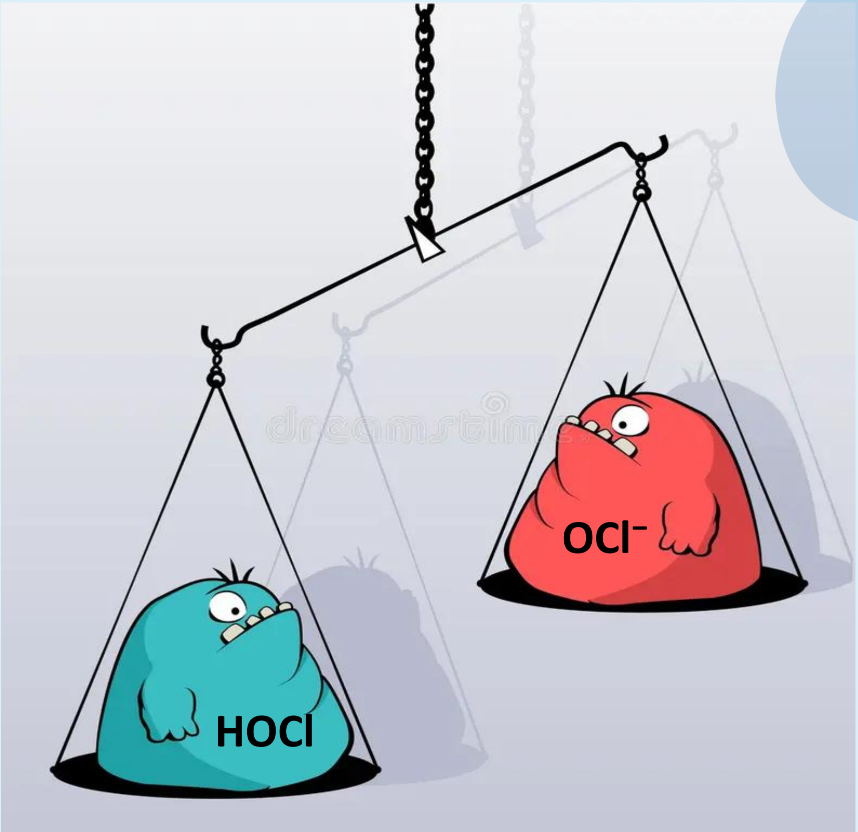
**In equilibrium** (50%: 50%)

| Solution pH | Chlorine as % HOCl | Chlorine as %OCl- |
|---|---|---|
| 4.0 | 95 | 0 |
| 4.5 | 100 | Trace |
| 5.0 | 100 | Trace |
| 5.5 | 100 | Trace |
| 6.0 | 98 | 2 |
| 6.5 | 95 | 5 |
| 7.0 | 78 | 22 |
| 7.5 | 50 | 50 |
| 8.0 | 22 | 78 |
| 8.5 | 15 | 85 |
| 9.0 | 4 | 96 |
| 9.5 | 2 | 98 |
| 10.0 | 0 | 100 |

- **pH 7.5** ⟶ HOCl = $OCl^-$

  **In equilibrium** (50%: 50%)

- Decreasing pH = Increases % HOCl

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- **pH 7.5** ⟶ HOCl = $OCl^-$

  **In equilibrium** (50%: 50%)

- Decreasing pH = Increases % HOCl
- Recommended to keep the pH below 7.5 for maximum disinfection
- Lowering the pH also increases the ORP

| Solution pH | Chlorine as % HOCl | Chlorine as %OCl- |
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| 4.0 | 95 | 0 |
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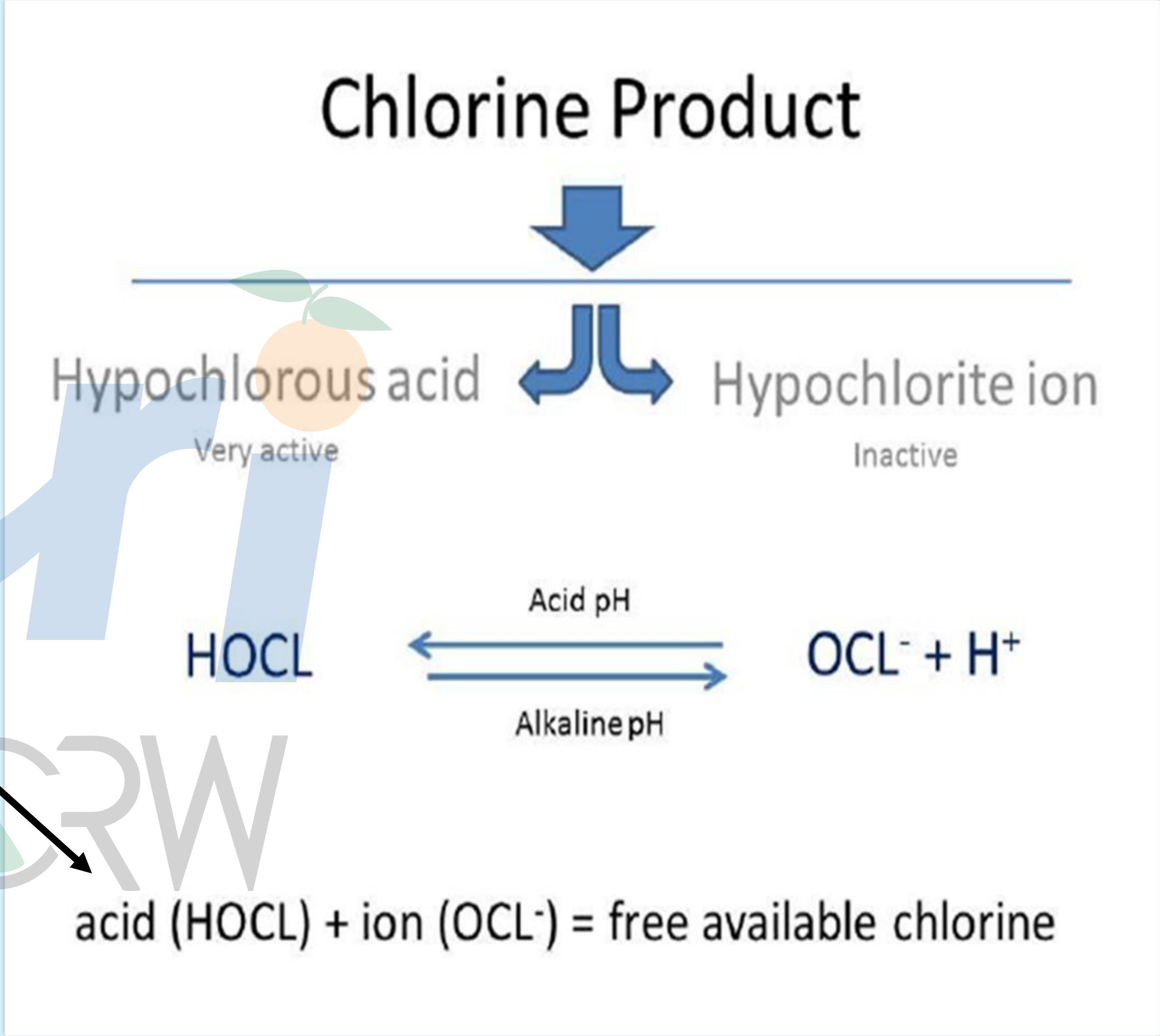
- Test for both total chlorine and free chlorine

- Free chlorine
- Chlorine **available for disinfection** (oxidative reaction)

- Free chlorine = HOCl + OCl-
- Regardless of ratio

- Testing for free chlorine
 = gives the total amount of HOCl and $OCl^-$ **NOT** their balance and oxidative potential.

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Determining relative % HOCl, using pH and free-chlorine ppm:

Example:

- 100 ppm free chlorine + pH 6.5

**= 95 ppm HOCl**

- 100 ppm + pH 8.5

**= 15 ppm HOCL**

| Solution pH | Chlorine as % HOCl | Chlorine as %OCl- |
|---|---|---|
| 4.0 | 95 | 0 |
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# Too high or too low pH?

Too high =
- Rapid drop off < pH 7.5
- At pH 9 won't kill any microbes.

| Solution pH | Chlorine as % HOCl | Chlorine as %OCl- |
|---|---|---|
| 4.0 | 95 | 0 |
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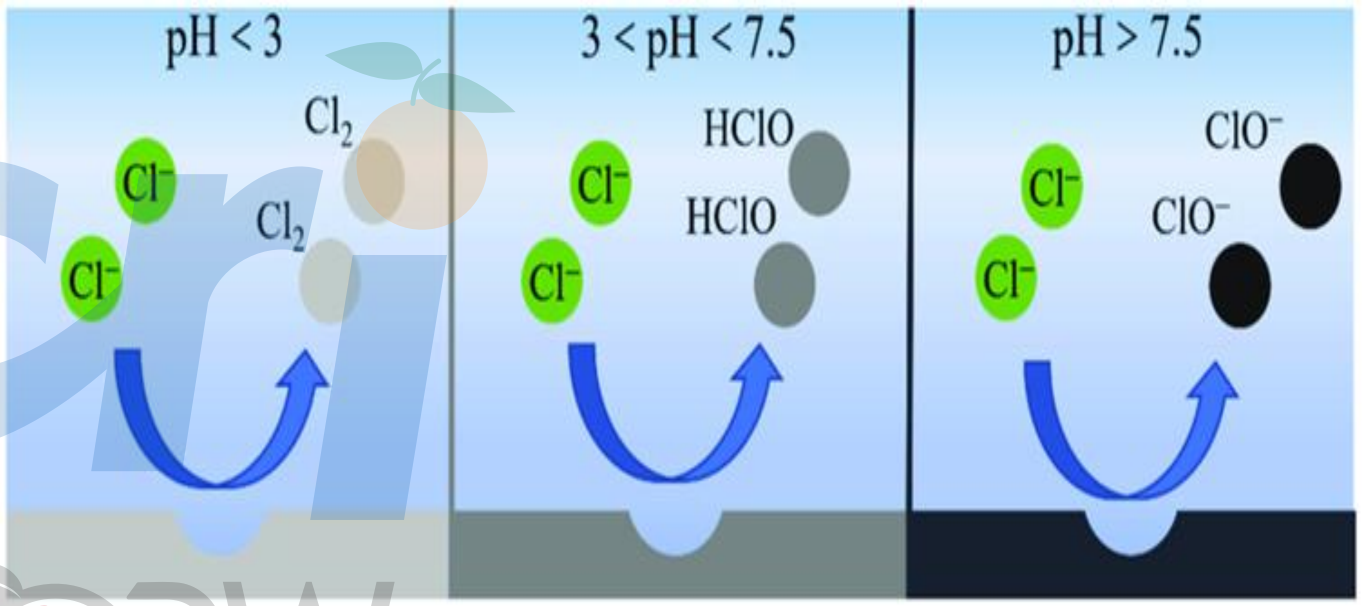
# Too high or too low pH?

**So why then not make your chlorine bath very acidic?**

- Too low pH
- Chlorine is unstable
- Chlorine gas is formed
- Escapes into the air
  - Loss of chlorine

- The more acidic the solution = The more corrosive



**CRI guidelines:**

- **pH** = 6.5 – 7.5

- Total chlorine = 150 – 200 ppm
- Free chlorine = 75 – 100 ppm
- Exposure time = ≥ 2 minutes

- **ORP** (Oxidative reactive potential) = 800 mv ideal (> 650 mV acceptable)

- Interferes with $Cl_2$:
  - Organic matter
  - Contaminants (iron and manganese) inactive $Cl_2$

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# Correcting the pH in the chlorine bath

- Measure and record pH and chlorine concentration as often as possible
- **Measure and adjust pH before adding $Cl_2$** – Extreme pH can form unwanted by-products
- Calcium hypochlorite (HTH) slightly increases the pH (due to lime) – **measure and adjust pH after application**
- Too low pH = Add soda ash and sodium bicarbonate
- Too high pH = Add acid (Hydrochloric acid, acetic acid, or PAA)
- Cannot adjust pH, increased contact time for better disinfection
- Residue overloading is not an issue, only chlorates are banned

# Other packhouse sanitisers

- **Clove oil – Sanitiser/ Fungicide**
  - pH-sensitive – Recommended to apply above pH 5.5
  - The integrity of the chemical is protected above this pH
  - Except with IMZ, pH 5 to 6 – Careful management needed

- **Chitosan-based products – Water polisher**
  - Optimal at pH 6 to 6.5
  - The integrity of the nanoparticles is protected within this pH range
  - Not corrosive
  - Automatic pH reader and adjuster
  - Manual readings advised every now and then – Ensures accuracy

# Other packhouse sanitisers

- **Peroxyacetic acid/ Peracetic acid (PAA)**
  - Not as pH-sensitive sanitisers compared to chlorine (apply at pH 4 - 8)
  - Most potent at pH 4.7 with a substantial decrease in effectivity above pH 9
  - Can damage fruit at too low pH, as well as increase the corrosivity

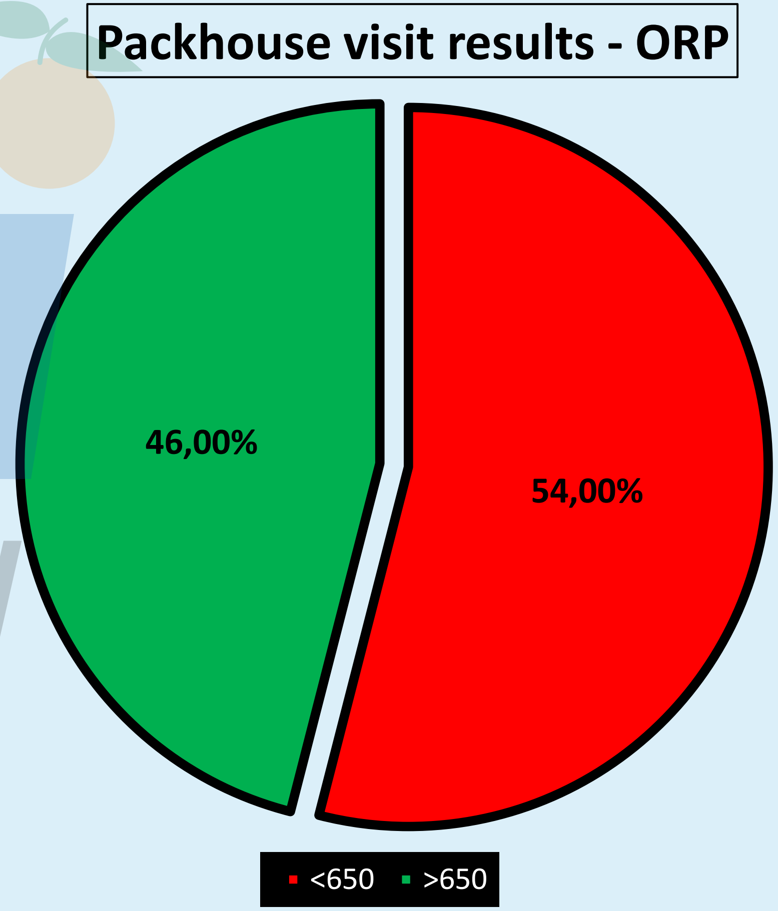
# Oxidation-reduction potential

- Told to measure the ORP in chlorine solutions.
- **BUT WHY?**
- Does it indicate…
- The sanitation potential?
- Level of dissolved oxygen?
- If your water is clean?

# Do packhouses monitor ORP levels?

- CRI guidelines:

| | |
|---|---|
| > 800 mV | Perfect |
| > 700 mV | Ideal |
| > 650 mV | Realistic |
| < 650 mV | Too low for effective chlorine sanitation. |



# What is ORP?

**Oxidation-reduction potential:**

- Conductivity of water

↑Conductivity = ↑ORP

# What is ORP?

**Oxidation-reduction potential:**

- The ability of chemical compounds to gain or lose electrons.

**Oxidation** = Loss of an electron
**Reduction** = Gain of an electron

- Solutions electron transfer capacity quantified = A value given
- ORP measured in millivolts (mV)

**+ *mV*** = strong oxidising conditions
**- *mV*** = strong reducing conditions

**Millivolt value is directly proportional to the oxidation potential of a solution**

# What is ORP?

- Can say that ORP measures the presence of oxidising and reducing agents.

- **Oxidising agents =** Dissolved oxygen ($O_2$) & Free /Available chlorine (HOCl)

**Increases ORP**

- **Reducing agents =** Decaying organic material & minerals (e.g. Calcium)

**Lowers ORP**

- Test for both total chlorine and free chlorine

- Free chlorine
- Chlorine **available for disinfection** (oxidative reaction)

- Free chlorine = HOCl + OCl-
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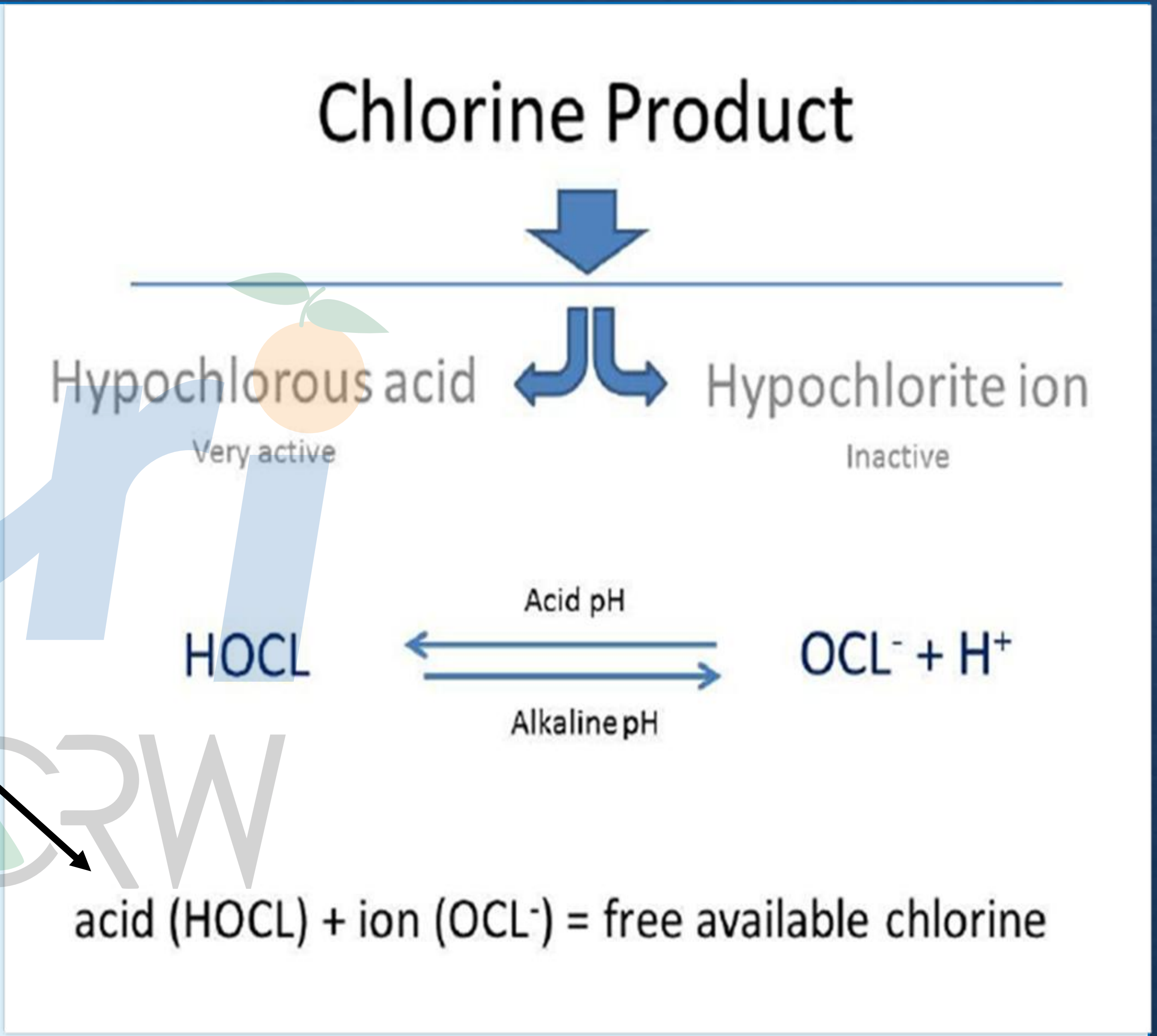

# What is ORP?

- Also indicates the water's ability to break down contaminants
- $O_2$ is a needed for the oxidative reaction to break down pollutants and deactivate pathogens.
- **Higher dissolved oxygen = Higher ORP**
- More sanitation potential to break down pathogens.
- $O_2$ binds to organic material and debris, which lowers the free levels.

**Cleaner water = more free $O_2$ = higher ORP**

# Why measure ORP?

- **To summarise:**

    - ORP levels are an indication of the **sanitation potential** of a solution.
    - IF the free **chlorine** concentration is **high** enough.
    - IF dissolved **oxygen** levels are **high.**
    - IF the **water** is **clean** enough.

- **How to keep ORP high?**
    - Filter water before and during use.
    - Measure and monitor.
    - Keep chlorine levels high and manage the solution's pH.
    - Replace the solution when dirty, daily if possible.
    - Clean the ORP meter's probes after use and store.

        - Don't let them dry out.

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# EC and TDS

- **EC – Electron conductivity**
  - Measures the solutions' ability to conduct an electric current.
  - **Concentration of ions or dissolved substances in a solution.**
  - i.e., the purity/ quality of water
  - MicroSiemens per centimeter (µS/cm) .

- **TDS – Total dissolved solids**
  - Combined concentration of all dissolved salts, metals, minerals (calcium, magnesium, chlorine, potassium, lead, iron, and sulphates) and ions in water.
  - All organic and inorganic substances in water.
  - ppm or mg/L
  - Good water quality = 0 – 600 ppm
  - Unsatisfactory = >1200 ppm (The levels of impurities in the water are too high)

# EC and TDS

- High EC and TDS reading?
  = Reduced effectiveness of chlorine sanitation

- Free chlorine binds with dissolved solids and is no longer available for sanitation and pathogen deactivation.

- Chlorine demand increases.
- More chlorine will need to be added.

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# Minerals in the water

- Certain minerals can make water more acidic or alkaline.

- Calcium and magnesium increase water hardness – Can increase the pH.
  - Bad for sanitation (chlorine, peracetic acid, etc.).

- Water naturally percolates through limestone, chalk, and gypsum deposits.
  - Dissolving minerals in groundwater – Incoming water is bad.
- Soft water – Rainwater and distilled water are naturally soft.
  - Low concentration of Ca and Mg, high levels of Na and K.
- Dissolved solids increase TDS.
- Dissolved iron (ferrous iron) oxidises chlorine – reduce amount of free chlorine.

# Organic matter

- ➢ Leaves, branches, rotten fruit, juice, pathogen spores, other microbes.
  - Decomposing OM – Consume sanitisers.

- ➢ Reacts with free chlorine – Reducing availability for pathogen inactivation.
  - Chlorine demand – Cannot be met.

- ➢ Reduces dissolved oxygen –> Sanitation potential (ORP) reduced.

- ➢ Nutrient source for microbes
- ➢ Increase in population – Biofilm formation – Degrades potassium sorbate.

- ➢ Physical shelter from sanitisers.
- ➢ Potentially harmful by-products like chlorate (EU MRL, 0.05mg/g) formed.

# Compatibility

- Don't mix sanitisers unless they are compatible
- Chlorine and peracetic acid should not be mixed with chitosan.
    - Do research before mixing anything.
- Incompatibility – Chlorine breaks down fungicides, so it is used up.

# Keep your water clean

- Empty and clean water tanks/ systems often.
- **We are not packing leaves and sticks!**
- Remove plant material and soil from the bottom.
  - Soil traps sanitisers.
- Measure and monitor free chlorine and ORP levels, or PAA concentration
- Coagulation or filtration during use. e.g. Sand filter systems.


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# Ensure accurate and reliable pH readings

- ➢ Different pH/ORP/ EC/ TDS meters and equipment available.
- ➢ Automatic reader and adjuster recommended.
- ➢ Don't rely on automatic system completely.
- ➢ Test with a portable, handheld meter now and then to confirm accuracy.


- ➢ For portable and desk-top meters:
- ➢ Carefull handling required, regular, proper cleaning, and correct storage
- ➢ Calibrate often (at least once a week) and serviced annually
- ➢ Do not use expired calibration chemicals and store in a cool, dark place

- How to manage your chlorine bath: https://www.citrusres.com/how-to-manage-the-chlorine-bath-by-catherine-savage/
- Calibrating and using a pH meter: https://www.citrusres.com/calibrating-a-ph-meter-by-catherine-savage/

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# Take home message

- Your water quality might be the reason for not seeing results with your sanitisers.
- **Everything was done right, but the quality was not taken into account.**

- Test your water parameters if performance is not up to standard.

- **If not considered and monitored:**
  - More regular top-ups needed to reach sufficient concentrations.
  - More frequent water replacements.
  - Potentially, higher decay levels.

# Cutting edges

- **Nr. 80** – pH Adjustment in the imazalil hot water bath
- **Nr. 271** – Key operational point of chlorine use in packhouses
- **Nr. 348** – Intensive management of critical control points in packhouses
- **Packhouse precautions** – Keith Lesar

# Thank you!

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