Citrox

Fruit & Vegetable Decontamination

The natural alternative to synthetic biocides for decontamination of fruits and vegetables

Introduction

- Farmers and fresh produce processors use every year thousands of tonnes of **chemicals** to treat their **fruit and vegetable produce**.
- Inevitably some of the chemicals remain on the food as **undesirable residues**.
- In addition to the chemical residues problem, the **risk of contamination** is increased because the produce is repeatedly handled during **preparation packing** and **transport**. It has been estimated that as many as twenty people may have handled produce before it reaches the consumer.
- Even where produce has been **organically grown** it can be exposed to deposits from vehicle exhaust fumes, atmospheric grime and insects.
- In many establishments preparing produce, the treatment given is no more than a **water wash**, and this has little effect since the substances applied during farming are designed not to be washed off by rainfall.
- Clearly a **more powerful and more effective** washing agent is needed to remove these harmful, and potentially toxic, residues.

Citrox range

- Citrox technology incorporates a truly holistic approach designed to increase the effectiveness and profitability of production processes.
- It includes "organic approved" systems using extremely safe and environmentally benign formulations.
- Citrox can offer systems applicable across the whole logistical operation from growing through processing and storage, to end-use. The care and protection of peripheral equipment can also be supported.
- Citrox extensive international field experience is available to support design of tailored trials ensuring you achieve the most cost effective package.

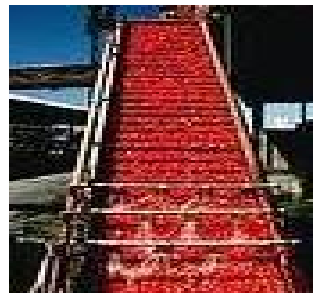
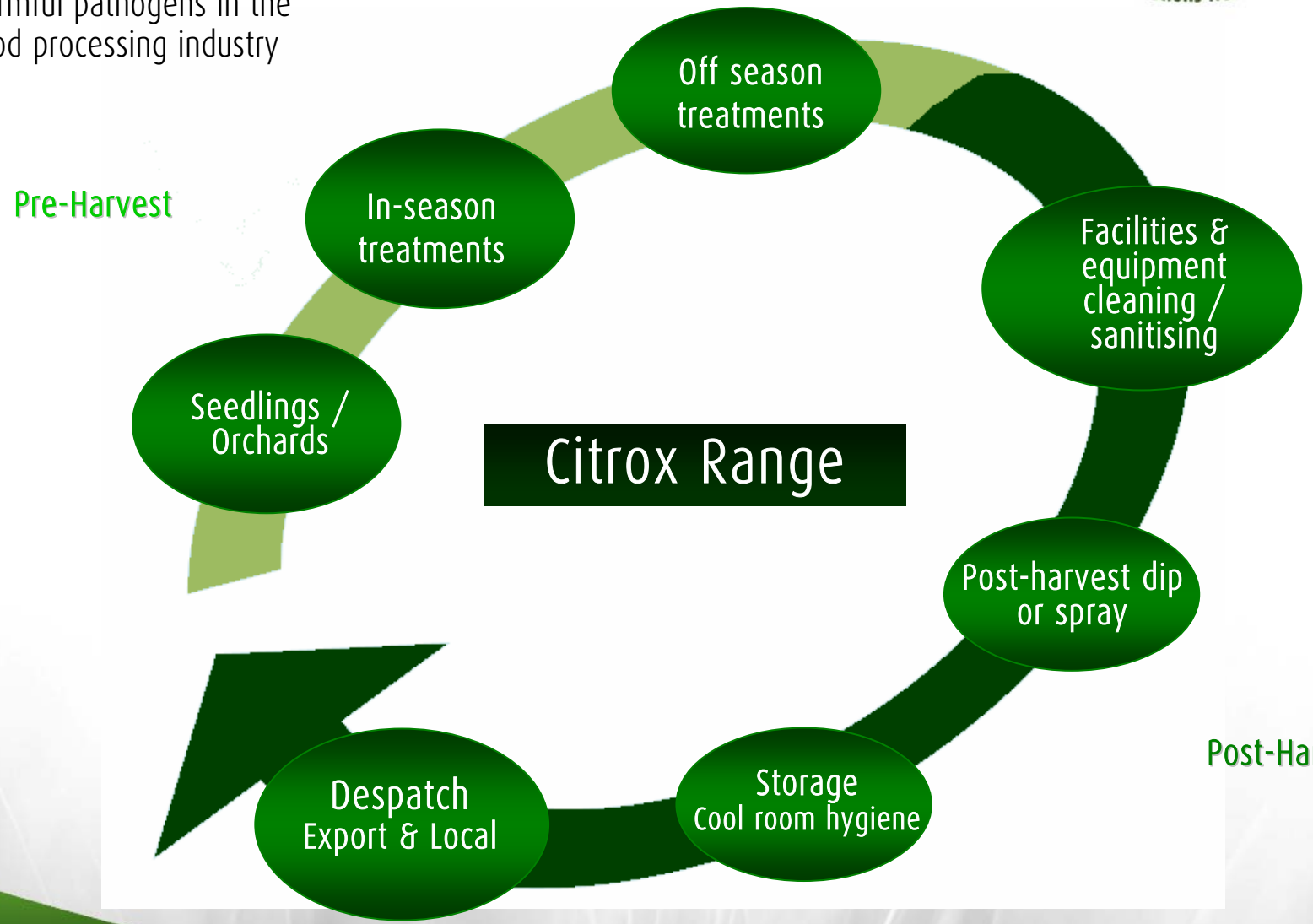


Figure 1: A holistic approach to the control of harmful pathogens in the food processing industry



Mission statement

- Citrox decontamination products are designed for:
  - Increasing the **shelf-life** of fresh cut and open-structured produce
  - Improving the **quality of produce** at the retail level
  - Supplying produce to the consumer which **tastes and looks good**
  - Providing an approach which is both **safe** and **environmentally sustainable**
  - Utilising systems which are simple, effective and predominantly "**organic**"

ProGarda™ Range

- ProGarda™ products have been specifically formulated for the **decontamination** of fruit and vegetables.
- These products are viable **alternatives** to the use of **chlorine** for decontaminating fresh fruit and vegetables. When applied at the correct dilutions, they will give (in accordance with BS EN1276) a guaranteed pathogenic **10^5 reduction**.
  - ProGarda™ Fruit & Vegetable Decontaminant (ref. **14WP**) is specifically designed for the decontamination of **fresh cut and open structured fruit and vegetables**. It can be applied via dipping, spraying or fogging techniques. The ingredients all comply to EU Regulation 2092/91.
  - ProGarda™ Skinned Fruit & Vegetable (ref **14T**) is specifically designed for the decontamination of **skinned fruit and vegetables** and is particularly effective when applied to produce with high organic/biofilm loadings.

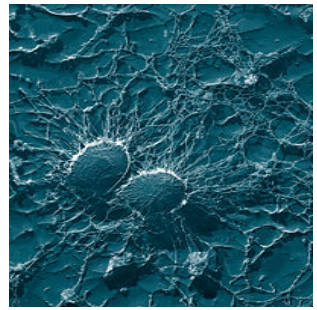
Pathogens tested to date

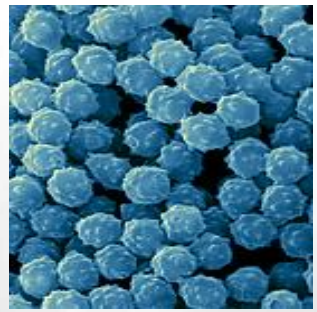
Bacteria

- Campylobacter jejuni
- Dipiodia natalensis
- Escherichia coli
- Geotrichum candidium
- Klebsiella pneumoniae
- Lactobacillus pentoaceticus
- Legionella pneumophila (NCTC 11192)
- Listeria monocytogenes
- MRSA (clinical strain)
- Mycobacterium fortutium (NCTC 8573)
- Proteus vulgaris
- Pseudomonas aeruginosa (ATCC 15442)
- Salmonella cholerasuis
- Salmonella typhimurium (DT004)
- Staphylococcus aureus (NCTC 6571)
- Staphylococcus pyogenes
- Staphylococcus sp.
- Streptococcus faecalis

Yeast and Fungi

- Aspergillus flavus
- Aspergillus niger
- Aspergillus terreus
- Botrytis cinerea
- Candida albicans
- Candida glabrata
- Chaetonium globosum
- Cladosporium
- Collectotricum sp.
- Fusarium sp.
- Geotrichum candidium
- Mucor sp
- Penicillium sp.
- Penicillium digitatum
- Penicillium funiculosum
- Penicillium italicum
- Penicillium roqueforti
- Phomopsis ortl
- Pullularia pullulans
- Pythium sp.
- Trichophyton interdigitale
- Trichophyton mentagrophytes





All of the pathogens/viruses are tested at independent laboratories.
Certificates & reports available on request.

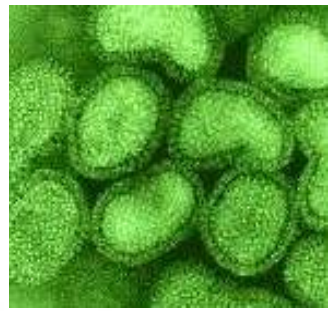
Pathogens tested to date

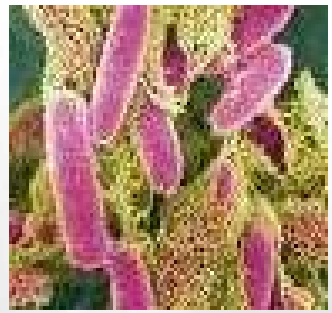
Viruses

- Human Rhinovirus - Retroscreen Virology
- Influenza A - Retroscreen Virology
- Human Immunodeficiency Virus (HIV) - Retroscreen Virology
- Urbani SARS - Retroscreen Virology
- African swine fever
- Avian influenza
- Foot & mouth disease
- Gumboro virus
- Herpes virus type 1 & type 2
- Herpes zoster
- Hepatitis A & B
- Newcastle disease
- Severe Acute Respiratory Syndrome (SARS)

Protozoa

- Histomonas meleagradis
- Giardia lamblia
- Entamoeaba histolytica
- Blastocystis hominis





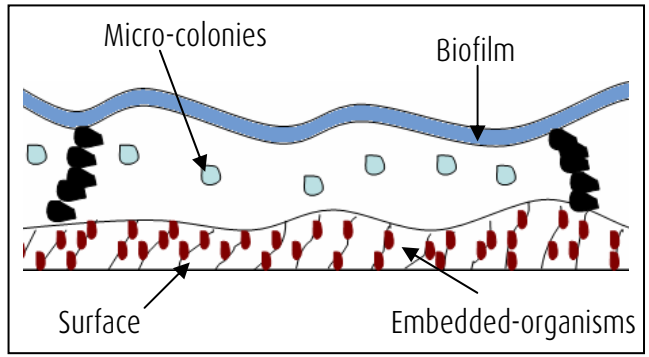
All of the pathogens/viruses are tested at independent laboratories.
Certificates & reports available on request.

Benefits – ProGarda™

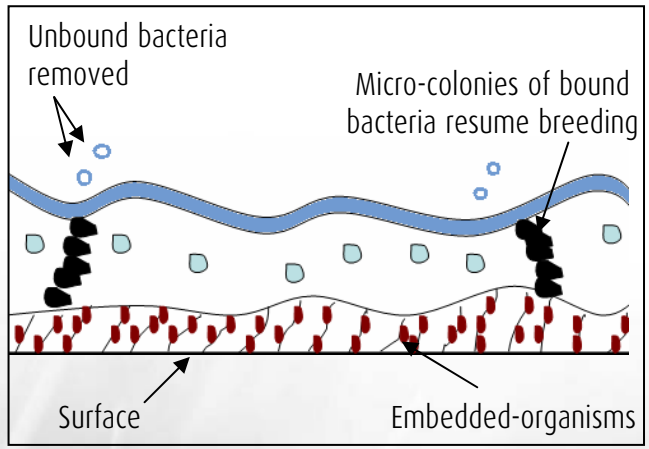
- Conforms to Organic Farming EU Regulation 2092/91
- Manufactured from completely renewable sources
- Effective in the presence of organic matter
- Breaks down biofilm
- Extends shelf-life and reduces pathogenic attack
- Non-toxic, hypo-allergenic, non-mutagenic, non-tainting, non-carcinogenic, non-hazardous to humans
- Conforms to BS EN 1276 (European Suspension Test) giving a guaranteed 5 log reduction

The biofilm effect

- The problem
  - The growth of **biofilms** on foods and food preparation surfaces is a potential **health risk**.
  - Attached micro-organisms are **more resistant** to conventional treatments than mobile material.
  - By way of example benzalkonium chloride destroys free **Listeria** cells in **30 secondes** but attached colonies (**biofilm**) survive **20 minutes.**



- The solution
  - Only **Citrox** products are powerful enough to **remove the biofilm**, kill the contained bacteria and provide residual effect to prevent further infection.
  - **Build up of attached bacteria** can develop substantial resistance to cleaning and sanitisation if allowed to develop over many hours.
  - **Cleaning programmes** MUST take the build up of biofilms into account when cleaning schedules are being determined, particularly over weekends.

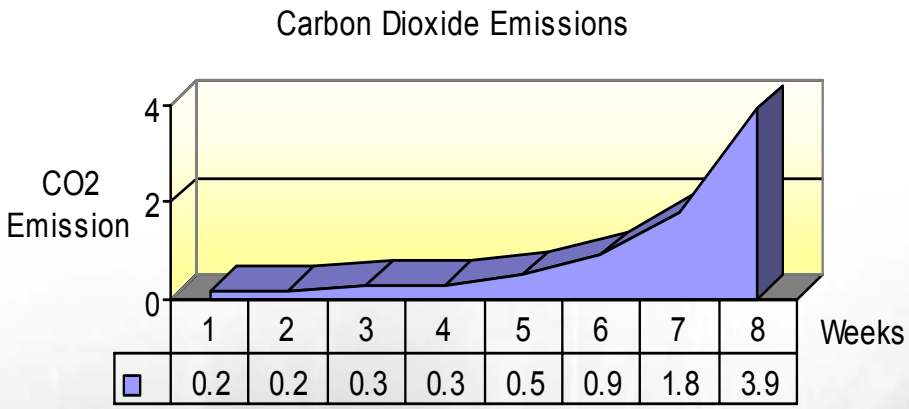


Biodegradability

- ProGarda™ Fruits & Vegetable Decontaminant products (14WP and 14T) are amongst the most readily **biodegradable** decontaminants commercially available.

Test method

- U.S. "Standard Test for Determining the Anaerobic Biodegradation Potential of Organic Chemicals" ASTM Standards, Section 11, (Water and Environmental Technology), procedure E 1196-2 pp879-901, 1993



Toxicity data

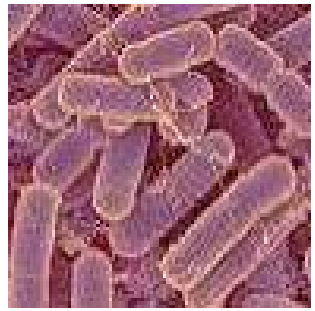
Tests Performed	Results	
	ProGarda™ "14WP"	ProGarda™ "14T"
Acute oral toxicity	LD50 >5,000 mg/kg on live weight	
Chronic toxicity (Acute oral with continuous feeding & reproduction study over 2 months)	LD50 2,500 mg/kg (rats)	LD50 2,250 mg/kg (rats)
Dermal toxicity	Not primary skin irritant, not corrosive	
Carcinogenicity	Hep G liver and human RKO colon cells, both products non-carcinogenic	
Mutagenicity tests	Liver and colon cells, both products non-mutagenic	
Eye irritation	Full strength - severe irritation, slight corneal iris injury 1% and 5% solutions - irritation and moderate erythema	
Inhalation	Closed chamber, 8 hrs/day, 5 day week, period 120 days No effects at concentrations of 150 mg/m^3 air	
Human patch studies	1% and 5% solutions produced no irritation or skin sensitisation	

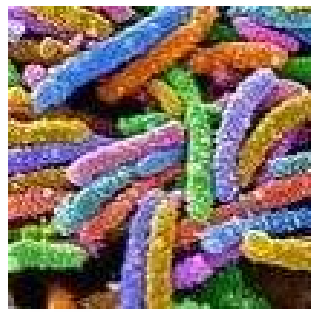
Toxicity comparison

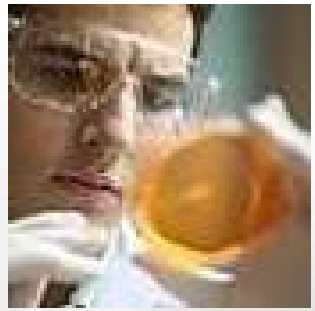
- A comparison has been made to demonstrate the difference between ProGarda™ natural active compounds and synthetic quaternaries.

LC50 measurement	ProGarda™	Benzalkonium chloride
in Hep. G liver cells	0.0025%	0.0006%
in RKO human colon cells	0.002%	0.0004%

- Based on the above tests Benzalkonium Chloride, tested at equivalent cationic concentrations (25% w/w), is up to **five times** more toxic per concentration level, for the cells tested than ProGarda™.







Benefits – ProGarda™ vs Chlorine

COMMON DISINFECTANT PROPERTIES	CHLORINE GAS	SODIUM OR CALCIUM HYPOCHLORITE	CHLORINE DIOXIDE	ProGarda™
Disinfection Action	High	High	High, better than chlorine	High, as good as chlorine dioxide
Specificity	Generally effective, including, viruses; reference sanitizer. Limited practical effect on parasitic spores (i.e. Crytosporidium). Oxidizer and metabolic poison.	Generally effective, including viruses; reference sanitizer. Limited practical effect on parasitic spores (i.e. Crytosporidium). Oxidizer and metabolic poison.	Generally effective. Recognized for biofilm penetration. Oxidizer.	Highly effective against viruses, gram+ and gram- bacteria, yeasts, moulds, fungi and sporicidal activity
Speed	fastest	fastest	fast-acting	fast-acting
Form	Compressed gas. On-site injection.	Concentrated hypochlorite solution or powder	On-site generation from precursors, or sodium chlorate and hypochlorite solutions. Some stabilized forms released on acidification.	Non-Toxic, Non-Corrosive, Non-Mutagenic, Non-Carcinogenic, Non-Tainting, Hypoallergenic liquid concentrate
Stability	Good	Good as powder, fair as liquid	Good	Excellent
Preparation	Easy	Easy	Complex equipment or procedure	Easy-User Friendly

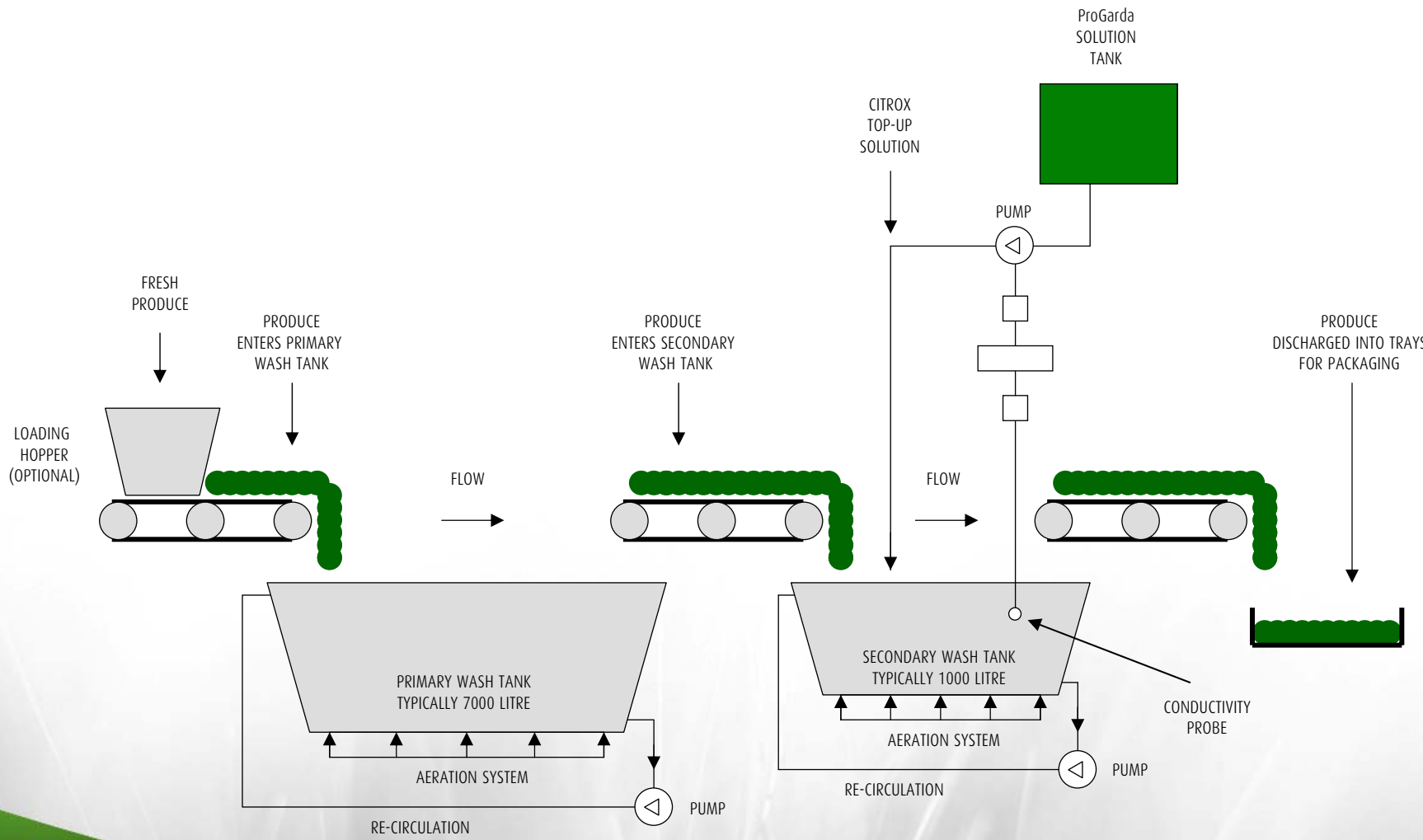
Benefits – ProGarda™ vs Chlorine

COMMON DISINFECTANT PROPERTIES	CHLORINE GAS	SODIUM OR CALCIUM HYPOCHLORITE	CHLORINE DIOXIDE	ProGarda™
Measurement	Easy. Functional relation to redox potential (ORP).	Easy. Functional relation to redox potential (ORP).	More difficult. Moderately functional relation to redox potential (ORP).	Easy-User Friendly
Stability	Good	Good	Moderate	Excellent
Irritancy	Low	Low	Very irritating vapors	N/A Non-Irritant
Vapors	None at correct pH	None at correct pH	Typical odor, yellow-green, dangerous	N/A Non-Volatile
pH impact	Most active at pH of 6-7.5	Most active at pH of 6-7.5	Most active at pH, best at 8.5	Most active at pH of 3-4 (weakly dissociated)
Temperature	For produce, generally cold water, but heated water up to 52°C in use	For produce, generally cold water, but heated water up to 52°C in use	Use at low temp to minimize vaporization. Some use of gaseous forms on produce.	Effective at all temperatures up to 100°C
Conc.	25 to 200ppm	25 to 200ppm, 20,000ppm limited approval for sprout seed disinfection	3 to 5ppm	2% w/w
Penetration	Poor	Poor	Poor	Excellent
Hard Water	Activity decreases in very hard water(>500 ppm)	Activity decreases in very hard water(>500 ppm)	No effect	No effect
Organic Matter	Reacts to from chloramines	Reacts to from chloramines	Little influence, even at high organic load	Effective in the presence of organic matter

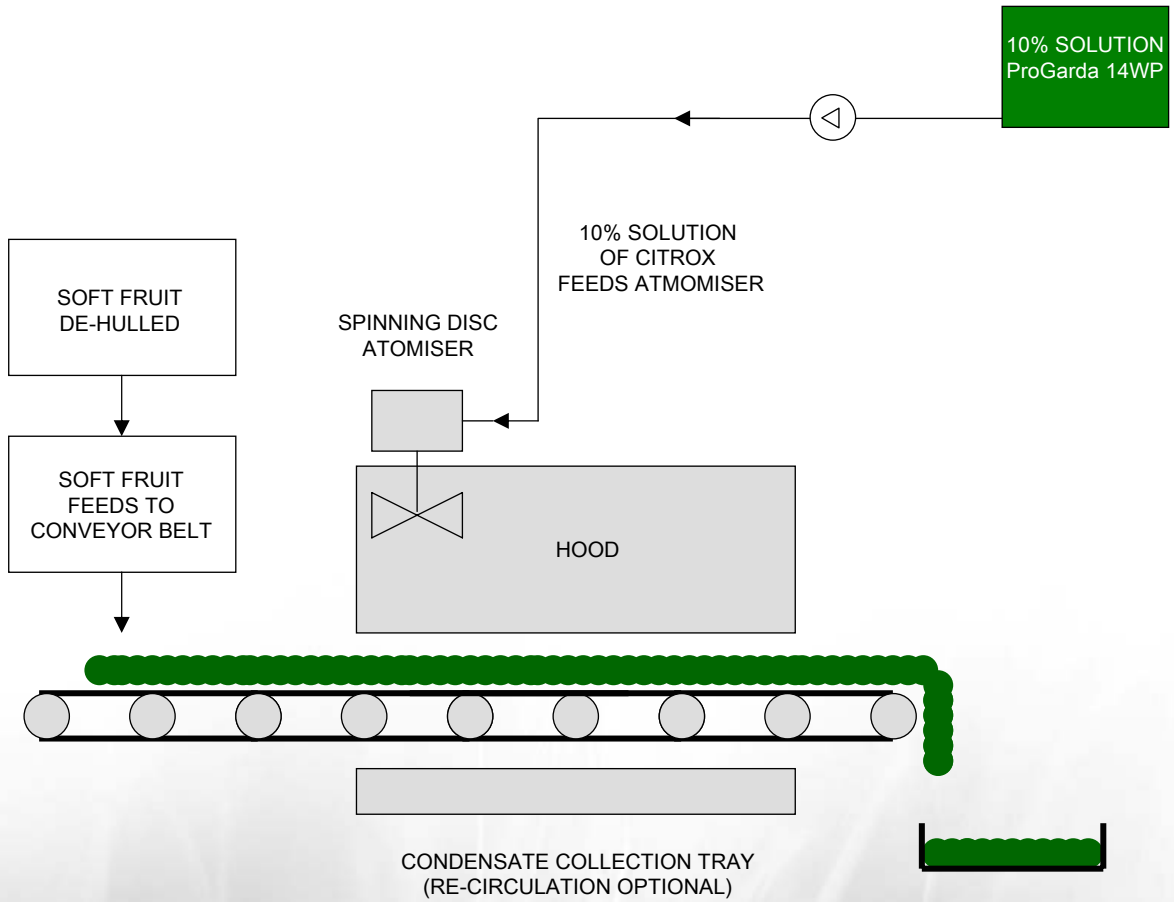
Benefits – ProGarda™ vs Chlorine

COMMON DISINFECTANT PROPERTIES	CHLORINE GAS	SODIUM OR CALCIUM HYPOCHLORITE	CHLORINE DIOXIDE	ProGarda™
Solution Corrosiveness	Slight to moderate	Slight to moderate	Very Corrosive at low pH	N/A Non-Corrosive
Corrosive off-gassing	Possible, through condensation	Possible, through condensation	Slight corrosion	N/A Non-Volatile
Other	Very corrosive below pH 6	Very corrosive below pH 6	Vapor space corrosion with high temp.	Non-Tainting, Non-Mutagenic, Non-Carcinogenic, Hypoallergenic
Best use	Food contact surfaces, water disinfection, smooth produce surfaces	Food contact surfaces, water disinfection, smooth produce surfaces	High organic load situations, smooth or complex produce surfaces, flume water disinfection	Fresh produce decontamination, Food contact surfaces (anywhere where rinsing is not required).
Disadvantages:	Requires tight pH and concentration control; highly corrosive, when improperly used; produces corrosive gas above 46°C.	Requires tight pH and concentration control; highly corrosive, when improperly used; produces corrosive gas above 46°C.	Complex preparation; corrosive in acid solution; very difficult to handle unless preparation is automated	None.

Decontamination process



Decontamination process



Microbiological activity

- **Tests** have been carried out all over the world on **ProGarda™** products, and have universally reported on their **favourable characteristics** for a wide range of uses.
- However it is essential, for customers' reassurance and confidence, that tests should be carried out under the **most rigorous, industry standard, conditions**.
- For this reason we have had **ProGarda™** produce decontaminants tested under the **Standard European Suspension Test** system. Many commercial products, which were acceptable under earlier and less rigorous tests, have failed under this new, more severe, test schedule i.e. they can only achieve a 10^2 reduction.

The European Suspension Test BS EN 1276: 1997

- This test requires that the product be effective at pathogen loading levels of up to 10^7, and to give 5-log reductions from this high level of initial contamination. Also, where the pathogen loading is not as initially severe (less than 10^7), and hence a 5-log reduction requirement is not realistic, the test looks for a reduction to a very low final pathogen level of less than 10^2.
- The tests were all carried out by completely independent laboratories.

Tests for minimum inhibitory concentrations

These tests were conducted on a range of micro-organisms (bacteria & fungi) and established minimum inhibitory concentrations for the basic **ProGarda™** actives.

Other certifications

In addition to the above successful tests, **ProGarda™** 14WP complies with the requirements of European Regulation 2092/91 and EC Directive 89/107/EEC.

Microbiological activity
ProGarda™ 14WP

- ProGarda™ 14WP is a highly effective, completely non-toxic, wash for **fruits & vegetables.**
- ProGarda™ range includes product for decontamination of **poultry, fish and meat**.
- The product has been used successfully by **dipping, spraying and fogging** techniques. Where large quantities of soft tissue produce (i.e. strawberries) have to be treated the use of a fogging technique has been found to give maximum utilisation efficiency (by factors of 3 to 5).

Organism	% Kill under conditions described	Test Procedure
E. coli	>99.999%	The product undergoes an efficacy screen based on the European suspension test. After five minutes contact time in dirty conditions at 25°C the kill rates are determined from the test dilution.
P. aeruginosa	>99.999%	
S. aureus	>99.999%	
Candida albicans	>99.999%	
Aspergillus niger	>99.999%	
Salmonella typhi murium	>99.999%	
Listeria monocytogenes	>99.999%	

Microbiological activity
ProGarda™ 14T

- ProGarda™ 14T is a highly effective, completely non-toxic, wash for skinned fruits and vegetables.
- The product has been used successfully by dipping, spraying and fogging techniques.

Organism	% Kill under conditions described	Test Procedure
E. coli	>99.999%	The product undergoes an efficacy screen based on the European suspension test. After five minutes contact time in dirty conditions at 25°C the kill rates are determined from the test dilution.
P. aeruginosa	>99.999%	
S. aureus	>99.999%	
Candida albicans	>99.999%	
Aspergillus niger	>99.999%	
Salmonella typhi murium	>99.999%	
Listeria monocytogenes	>99.999%	

Sensory advantage

(Trialled Against Other Commercially Available Products)

Visual quality scores over a 5-day trial

Key benefits

1. No change
2. Slight edge or vein effects
3. Marked surface effects
4. Gross discolouration

Treatment	Days				
	1	2	3	4	5
1% **ProGarda™** 14WP	1	1	1	1	2
1% **ProGarda™** 14T	1	1	1	1	2
Competitive product 1	1	1	2	2	4
Competitive product 2	1	1	1	3	3

Estimation of residues

ProGarda™ 14W Plus has a total concentration value of 222g / 1000g (222mg/ml)

14W Plus is used as a 0.5% wt/wt solution in water

→

Processing concentration:

$\frac{222 \times 0.5}{100}$ = 1.11mg/ml

Assume the produce is lettuce

→a 2% wt/wt processing water is retained on leaves

(value supplied by the two largest salad wash companies in the UK – Bakkavör and Natures Way)

→

$\frac{1.11 \times 2}{100}$ = 0.0222mg

Citrox residue is 22.2 ppm (wt/wt)

Residual value (based on flavonoid content) = 22.2 x 0.054 = **1.2 ppm**

1g of iceberg lettuce contains 34 ppm of flavonoids

...so there are 28 times more flavonoids inside the lettuce itself than there are Citrox residues on the surface

Applications

Fruits & Vegetables Decontamination

- Leaf salads
  - Lettuce, Leafy/flowery vegetables, Broccoli, Cauliflower, etc
- Vegetable fruits
  - Immature: cucumbers, peppers etc.
  - Mature: melons, tomatoes etc.
- Underground vegetables
  - Root vegetables: carrots etc.
  - Bulbs: onions etc.
  - Tubers: potatoes etc.
- Stone fruits
  - Apricots, plums etc.
- Vine fruits
  - Grapes etc
- Berries
  - Strawberries, blueberries, raspberries etc.
- Citrus fruits
  - Lemons, grapefruits, oranges etc.
- Tropical/exotic fruits
  - Pineapples, papayas etc.

Key products: Pre- and Post-harvest

PRODUCT	DESCRIPTION	USE
ProAlexin™ Phyto-Elicitor – Liquid	**Phyto-Elicitor – All crops (fruits, vegetables, cereals,..)**. Complies with EC 2092/91 organic farming regulation.	Recommended dilution: approx. **0.075%**.
ProGarda™ Fruit & Vegetable Decontaminant	Decontaminant for **soft fruits** and open structured **vegetables**. Complies with EC 2092/91 organic regulation.	To be used in dip bath or as a spray at recommended dilution of approx. **0.5%**.
ProGarda™ Skinned Fruit & Vegetable Decontaminant	Decontaminant for **skinned and non-porous fruits**. Particularly recommended where organic residues and biofilm are a problem.	To be used in dip bath at recommended dilution of approx. **1% to 2%**.

Key products: Cleaning & Sanitising

PRODUCT	DESCRIPTION	USE
ProSino™ Foaming Cleaner	Heavy-duty non-toxic, non-corrosive **foaming** cleaner & sanitiser with excellent oil/soil detergency properties.	To be used at approx. **2%-5%** dilution (depending on degree of soiling) for the cleaning of installations and equipment.
ProSino™ Non-foaming Cleaner	Heavy-duty non-toxic, non-corrosive, **non-foaming** cleaner & sanitiser.	To be used at approx. **2%-5%** (depending on degree of soiling) in C.I.P. systems and agitator machines.
ProSino™ All-purpose Sanitiser	All-purpose non-toxic, non-allergenic, natural surface (facilities, floors, equipment, utensils,..) terminal rinse **sanitiser**. Conforms to EU Regulation 2092/91	- To be used at approx. **0.5%** dilution to sanitise installations, equipment and utensils in the farm (including foot dips). - **2%** dilution rate for fogging of sheds/rooms.

Key products: Personal Care

PRODUCT	DESCRIPTION	USE
ProCaro™ Industrial Hand Soap	Naturally derived skin friendly **hand soap**.	Use neat via dispensing equipment; rub in and rinse with fresh water for hand cleaning.
ProCaro™ Hand Scrub Soap	**Natural scrubbing hand cleaner**. Contains pumice. Cleans and sanitises the dirtiest hands and will exfoliate the skin.	Use neat via dispensing equipment; rub in and rinse with fresh water for hand cleaning.
ProPharma™ Hand Sanitiser - Foam	**Hand sanitising foam**. Long lasting residual effect. Non-toxic and hypoallergenic. No alcohol.	Use neat via dispensing equipment. Install in wash rooms, lobbies,... Do NOT rinse off.
ProPharma™ Hand Sanitiser - Gel	**Hand sanitising gel**. Long lasting residual effect. Non-toxic and hypoallergenic. No alcohol.	Use neat via dispensing equipment. Install in wash rooms, lobbies,... Do NOT rinse off.

"Nothing in the world is as powerful as an idea who's time has come."

Victor Hugo

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