TwinOxide®
Total Water Disinfection Concept

# TWINOXIDE®:A BROAD-SPECTRUM BIOCIDE FOR FRUIT & VEGETABLE WASH AND PROCESSING

## A SPECIAL NOTE ON THE APPLICATION OF TWINOXIDE® IN THE BANANA PROCESSING PLANT AND OTHER NECESSARY RECOMMENDATIONS

### What is TwinOxide®

TwinOxide® is a two-component powder kit that delivers a 0.3% chlorine dioxide solution. TwinOxide® does NOT generate by-products known from chlorine dioxide (e.g. chlorite, chlorate, free chlorine). TwinOxide® can be considered far more advanced than chlorine dioxide generated in classical ways. Further TwinOxide® is NOT EXPLOSIVE and has a chemical halftime of 30-60 days (depending on storage conditions). Like ozone, chlorine dioxide is soluble as a true gas. The $ClO_2$ molecule remains a true gas in solution-making it more energetic and able to reach all points in a system. Because it is a true gas and soluble in virtually anything, it can penetrate the bacterial slime layers (biofilm). Finally, TwinOxide® breaks down to sodium chloride. This along with the failure to form toxic and carcinogenic chlorination by-products/toxic organic or inorganic by-products makes TwinOxide® the most eco-friendly biocide that can be used.

### Fruit & Vegetable Wash

Sources of contamination are many. Direct or indirect contamination from animal and human faeces can occur at many points in the fresh-produce chain. Pre-harvest contamination can come from irrigation water, improperly composted manure used as fertilizer, faecal contamination from feral and domestic animals and from workers. On harvesting, contamination may be caused by improperly cleaned harvesting equipment and transport. After harvesting, contamination may occur from wash water and cross-contamination from other vegetables.

During processing, proper storage, control of temperature and hygiene are important in limiting contamination and growth of pathogens. The quality of the water used in production and processing is of prime importance since water can contaminate, or spread contamination through, a large amount of product. Pathogens can be transmitted to product handled can be infected workers. Cutting and shredding can be a major source of in-plant contamination since the equipment used can be difficult to clean and has been identified as an important site for the accumulation of pathogens, particularly of L. monocytogenes.



While great care and attention is often taken to minimize the risk of infection from processing staff and other food handlers, relatively ineffectual biocides and disinfectants are used to treat process water and equipment. Beware, that even a single contaminated batch of food, one poor or erratic output can destroy your company's reputation. Manufacturers offer a large number of disinfectants, each claimed to be the best on the market. Commonly available contain chemicals of the following groups:

1. Chlorine and chlorine releasing compounds.
2. Quaternary ammonium compounds.
3. Amphoteric (ampholytic) compounds.
4. Phenolic compounds.
5. Peracetic acid

The disadvantages of the above chemicals are many and their disinfectant properties are limited by many factors; some of which are listed below:

1. The concentration of available chlorine should be as high as 200-300 mg/litre.
2. Peracetic acid and Quats are only effective only in high doses. Peracetic acid produces acetic acid, which is very useful nourishment for micro organisms-therefore bacteria grow/enlarge more after using peracetic acid.
3. To reduce the breakdown during storage, the hypochlorite solution should be maintained at pH 9-11 i.e. has pH limitation.
4. The disinfectant capabilities are diminished in the presence of fats, oils, proteins, body fluids etc.
5. Not effective against wide range of bacteria, spores, fungi and viruses.
6. The hypochlorite is more efficient if the concentration and temperature are raised and/or the pH is lowered.
7. These are temperature and contact time dependent (long exposure is required).
8. These are very corrosive and staining to common metals.
9. Organic material consumes chlorine and reduces the disinfecting capacity.
10. Many develop toxic gases and irritate the skin of personnel.

Chorine is often used as a treatment for wash water, although there are frequent problems with taste tinting and unpleasant working environments at high levels.

TwinOxide®, a very powerful biocide, has a number of advantages over other products commonly used in the industry. TwinOxide® is proven against botulism organisms and other food contaminants such as salmonella, staphylococcus, streptococcus etc. Even most resistant strains of fungi are completely destroyed in 60 seconds. Tricophyton mentagrophytes are killed in 5 minutes. The most difficult organisms of all-the spore formers are destroyed in 5 minutes - many many times faster than most chemicals; yet TwinOxide® is safe enough and requires no restrictions on use in direct contact with food.

## The answer to traditional problem - the alternative for chlorine

TwinOxide® is a disinfection solution that unites the positive characteristics of chlorine (low chlorine acid) without the negative effects of chlorine and in addition to that provides a substantial stronger resultant disinfectant with a very broad pH- value range (4-10).

TwinOxide® - Chlorine dioxide is applicable in water and avoids the hazardous effects on the human body (no irritation of mucous glands or membranes and is environment friendly) and compared to ozone is much more stable and economical.

The TwinOxide® two-component concept enables, for the first time, availability in soluble form without the need of very expensive equipment to use it. Due to this innovative characteristic the TwinOxide® two- component concept has been added to the list of storable disinfectants according to the German Regulation DVGW-Arbeitsblattes-W291.

## What others say

The WHO guidelines for drinking water quality recommend chlorine dioxide as a persistent residual for continued microbial control.

Many tests of applications of chlorine dioxide have been executed. In order to quote one of them the following: “There’s practically nothing it can’t destroy. It has killed every virus and bacteria that it has ever been tested on, including fungi and even parasites,” said Dr. Michael Barza, director of medicine at Boston’s Caritas Carney Hospital (http://www.caritascarney.org/home/default.asp).

This becomes indispensable in both hospitals and the food industry, where transmission of pathogenic microorganisms can be a major problem.



Staphylococcus aureus is one of the common pathogens found at hospitals, while Listeria monocytogenes, Escherichia coli and Salmonella typhimurium like to hang out near food. Some of the problems these nasties cause include vomiting, meningitis, miscarriage and abscesses.

“It (chlorine dioxide) works in different ways on different microorganisms. In bacteria it damages the cell membrane; in viruses it denatures the viruses,” Barza said. “It bursts them – it works like a little nuclear bomb.”

Despite its devastating effect on harmful microbes, Barza said, chlorine dioxide, when used in small doses, poses no risks for humans.

## The comparison

| Criteria | TwinOxide® - Chlorine dioxide | Chlorine |
|---|---|---|
| Bio film eradication in the water circuit | TwinOxide® penetrates the bio-film completely and eradicates very well. | In drinking water concentration is limited, hence no eradication due to lack of penetration of the bio-film. |
| Deodorization | Excellent deodorization characteristics and therefore smell and taste causers in water like Phenols, Amines and, Algae are avoided or not produced. | Production of smell and taste influencers by reaction with Phenols, Amines and Algae. |
| pH-value dependability during disinfection. | Disinfection is pH-value independent within a bandwidth of 4 < pH < 10. Effective disinfection of concrete based pipeline circuits also. | Disinfection only at pH values < 7.5. Limited disinfection of concrete based pipeline circuits. |
| Building of cancer causing THM’s | No THM building in drinking water. | Strong building due to reaction with organic material in water. |
| Building of mucous glands or mucous membranes irritating chloramines. | No reaction with primary or secondary amines and therefore NO chloramines are built. | All amines are transformed to chloramines when it reacts with chlorine. |

## TwinOxide® germicidal spectrum

***Bacteria:***

| | |
|---|---|
| Pseudomonas Aeruginosa | Campylobacter Jejuni |
| Pseudomonas Specie | Flavobacterium Species |
| Enterobarcter Cloaceae | Yersinia Enterolitica |
| Enterobarcter Hafnia | Clostridium Sporogenus |
| Proteus Vulgaris | Clostridium Dificile |
| Klebsiella Pneumoniae | Clostridium Perfingens |
| Salmonella Typhi | Fusobacterium Nucleatum |
| Salmonella Enteriditis | Bacillus Subtilis |
| Salmonella Gallinarum | Bacillus Circulans |
| Salmonella Typhimurium | Bacillus Megatarium |
| Salmonella Choleraesuis | Bacillus Cereus |
| Salmonella Typhosa | Bifedibacter Liberium |
| Corynebacterium Nucleatum | Staphylococcus Aureus |
| Sarcinae Lutae | Staphylococcus Epidermia |
| Streptococcus Pyrogenes | Streptococcus faecalis |
| Strep 1, 2, 3 | Mycobacteroi Bovis |
| Mycobacterium Smegmatis | Mycobacterium Kansaaii |

***Fungi:***

| | |
|---|---|
| Candida Albicans | Tricophyton Rubrum |
| Scopulariosis Species | Aspergillus Niger |
| Trichophyton Mentagrophytes | Aspergillus Flavus |
| Mucor Species | Fusarium Specie |
| Sachromyces Cerevisiae | Fonsecaea Pedrosoi |

***Virus:***

| | |
|---|---|
| Herpes Virus I | Poliovirus |
| Herpes Virus II | Encephalomyocerditis (EMS) |
| Adenovirus Echovirus | Vaccina Virus |
| Coxsakievirus | Vesicular Stomatitis Virus (VSV) |
| Influenza | Para Influenza |
| Feline Parovirus | Bluetongue Virus |
| Mouse Flu | Mouse Hepatitis Virus (MHV) |
| Minute Virus Of Mice (MVM) | Mouse Encephalomyelitis Virus |
| New Cattle Disease Virus | Mouse Polio Virus (MEV) |
| Iridovirus | Pertiviries – Togaviridae |

***Others:***

| | |
|---|---|
| Vibrio Cholerae | Culex Quinquifasiatus |
| Mycoplasm | |

## Application & Dosage

TwinOxide® chlorine dioxide can be used at much lower doses than typical halogen antimicrobials with far superior microbial control. Its aggressive attack on biofilms ensures less fowling of piping and practically eliminates bacterial "seeding" of process waters. Chlorine dioxide doesn't produce halogenated organic byproducts, which are serious problems associated with chlorine and bromine compounds.

## Application in Banana Wash and Processing

TwinOxide® provides excellent microbiological control for the food & beverage processing sectors in areas including brewing and bottling, fruit and vegetables (FDA approved application), poultry and other meats, fish, and dairy processes. TwinOxide® (pure $ClO_2$) also provides excellent microbiological control in flume waters, packaging operations and process disinfection.

Banana fruits are available in plenty in the Tropical countries and a sizeable quantity of this fruit is wasted due to poor transportation and storage facilities.

Therefore processing and product development using bananas is of utmost importance. Various processed products like figs, clarified juice, banana powder, flour, starch, jam, chips, stem candy and fermented products like ethanol, brandy and beer are prepared and used commonly in these countries.



## Application of TwinOxide® in Banana Washing

It is estimated that Staphylococcus aureus is responsible for between 13 and 30% of food borne illness occurring each year. Most consumers may not wash bananas before peeling, which could transfer food pathogens to the banana pulp becoming potentially dangerous for very young children and the elderly. A Quantitative Risk Assessment Model was developed for predicting potential microbial hazard of S. aureus contamination on bananas from harvest through retail. Identifying potential contamination nodes during harvest, rinsing, packing, loading, shipping, degreening and retail markets could reduce human illness associated with eating raw produce. The objectives of this study were to construct a quantitative microbial risk assessment mode, develop a computer simulation program, select and determine growth and survival models of S.aureus from the time the banana is harvested until it reaches the supermarket. As a result of primary model simulation, the changes of concentration and prevalence of S. aureus have been evaluated during the defined banana production nodes.

Preliminary microbiological studies showed that banana peel and pulp could support the growth of S. aureus at room temperature. Over six-day period bacteria on the intact banana peel increased from 3.2X106 CFU/cm2 to 1.5X107 CFU/cm2. The model simulation results showed that a probability frequency distributions for S. aureus prevalence during banana production in the following nodes: harvest 1.45X108 CFU/cm2, rinsing 2.3X106 CFU/cm2, packing 1.8X107 CFU/cm2, loading1.8X105 CFU/cm2, shipping 3.6X105 CFU/cm2, degreening 2.3X107 CFU/cm2andretail 2.7X107 CFU/cm2.

## Treatments to reduce microbial contamination

Over the past few years, food safety has become and continues to be the number one concern of the fresh produce industry. A "Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables," was published by the U.S. Food and Drug Administration in October 1998.

1. Prevention of microbial contamination of fresh produce is favored over reliance on corrective actions once contamination has occurred;
2. In order to minimize microbial food safety hazards in fresh produce, growers, packers, or shippers should use good agricultural and management practices in those areas over which they have control;
3. Fresh produce can become microbiologically contaminated at any point along the farm-to-table food chain. Human and/or animal faeces are the source of microbial contamination of fresh produce;
4. Whenever water comes in contact with produce, its quality dictates the potential for contamination. The potential of microbial contamination from water used with fresh fruits and vegetables must be minimized;
5. The use of animal manure or municipal biosolid wastes as fertilizers should be closely managed in order to minimize the potential for microbial contamination of fresh produce.

Clean water containing an appropriate concentration of sanitizers is required in order to minimize the potential transmission of pathogens from water to produce, from healthy to infected produce within a single lot, and from one lot of produce to another, over time. Waterborne microorganisms, including post-harvest plant pathogens and agents of human illness, can be rapidly acquired and taken up on plant surfaces. Natural plant surface contours, natural openings, harvest and trimming wounds and scuffing can provide points of entry as well as safe harbor for microbes. When located in these protected sites, microbes are largely unaffected by common or permitted doses of post-harvest water sanitizing treatments. It is therefore essential that the sanitizer concentration is sufficient to kill microbes before they attach or become internalized in produce. The concentration of sanitizer is important in some pre-harvest water uses (such as spraying pesticides or growth regulators) and in all post-harvest procedures involving water, including washing, cooling, water-mediated transport (flumes), and post-harvest drenching with calcium chloride or other chemicals.

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## Processing steps of Banana

***Step 1*** Bananas are dumped from the truck onto a conveyor. Coarse rinse with town water sprays to remove dirt etc.
***Step 2*** Bananas fall into flume tank (20 m3). The flume water is pumped to the sorting conveyor and back in a closed circuit with the bananas. Operators remove unacceptable product.
***Step 3*** Make-up condensate water is continually added (5 m3/hr). Chlorine Dioxide is dosed into the flume water to maintain concentration of 0.2 - 0.4 ppm of $ClO_2$. pH of the flume water goes to 4.0 and this is not corrected as it is acceptable.



## Advantages/benefits

- Low concentration of chlorine dioxide is very effective in destruction of moulds on the bananas. These moulds would negatively affect the past production process if present.
- Low concentration of chlorine dioxide is very effective in destruction of moulds in the flume water. If untreated, the moulds attach to surfaces of tanks and flumes and look like “meat”. Eventually, they foul screens and smell.
- Chlorine dioxide effective at pH 4.0
- No smell for operators
- Very low running costs
- No chlorinated organic by-products.

## Dosage and application recommendation

| Disinfection Object | Dilution Ratio | Concentration (in ppm) | Contact Time | Method |
|---|---|---|---|---|
| Apparatus, Vessel, Instruments, Product Lines | 1:60 | 50 | 5-10 minutes | Immersion or aspiration, wiping (three times) |
| | | 80-120 | 30 min | Spray at 0.5 kg/10 $m^3$ vacuum |
| | | 2000 ppm | 3-8 hr. | Put the liquid into an open vessel and aspirate at 0.1-0.2 kg/100 $m^3$ vacuum |
| Fruits Washing | 1:60 | 50 | 5-10 min | Immersion |
| Process water | 1:3000 | 1 | 30 min | Dilute to use |
| Hands of operators | | 80-100 | 0.5-1min | Immerse and air dry after wash with hand cleaner |
| Clothes | | 50-80 | 5 min | Immerse and air dry after cleaning |
| Boots pool | | 150-200 | 30 sec | Immerse |

## For storage and transportation

| Disinfection object | | Dilution ratio ML(kg):Water(kg) | Concentration (mg/L) | Time (min) | Usage method |
|---|---|---|---|---|---|
| Pre-disinfection before store | Fruit | 1:25-1:37.5 | 80-100 | 1-2 | Immersing and slightly drying |
| | Vegetable | 1:60 | 50 | 1-2 | Wet by aspiration |
| Disinfection of depot before store | | 1:25-1:37.5 | 80-120 | 30 | Spray at 0.5kg/10m3 vacuum |
| | | | 2000 | 3-8 hr | Put the liquid into an open vessel and aspirating at 0.1-0.2kg/100m$^3$ vacuum |
| Disinfection of depot in the process of store | | 1:25-1:37.5 | 80-100 | 3-5 time/day | Spray at 0.5kg/10m$^3$ vacuum |
| | | | 2000 | 3-5 time/day | Put the liquid into an open vessel and aspirating at 0.1-0.2kg/100m3 vacuum |
| In the process of store | | Disinfections as pre-disinfection before store | | | |
| Pre-disinfection before transport | Fruit | 1:25-1:37.5 | 80-100 | 1-2 | Immersing and air drying |
| | Vegetable | 1:40 | 50 | 1-2 | Wet by aspersion |



### Methods of Detecting Residual $ClO_2$ Content of Circulation Water

There are several kits produced by LaMotte Chemical and the Hach Company which rely on the DPD method of detection and some of which are calibrated directly in $ClO_2$ content. The concentrated $ClO_2$ may be analyzed by a spectrophotometer measuring the absorption of the solution at 390 mm for free $ClO_2$ and the total $ClO_2$ may be measured by the Potassium Iodide-Thiosulfate method (Standard Methods of Analysis: $ClO_2$).

Merck Company color comparator Kit for chlorine dioxide measuring is also available. Product specification:
Aquaquant Chlorine Dioxide range 0.00-0.55 mg/l Chlorine Dioxide, pack of 300 tests, item number: 1.18754.0001.

### Online Measuring

TwinOxide® is measured online with a chlorine dioxide sensor. The sensors should be calibrated according to the manufacturer's directions.

### Vegetable washing

Vegetables of all kind are washed, cut and packed (e.g. in plastic bags). Customers are supermarkets and fast food producers.

### Previous treatment

Usually chlorine is used for microbiological control with concentrations varying between 100 - 150 ppm.

### Problems with previous treatment

Chlorine created a smell problem during processing in the processing hall with operators complaining of eye and skin irritation. pH very often above 7.5 where microbiological treatment is often not effective with chlorine.

### Batch washing

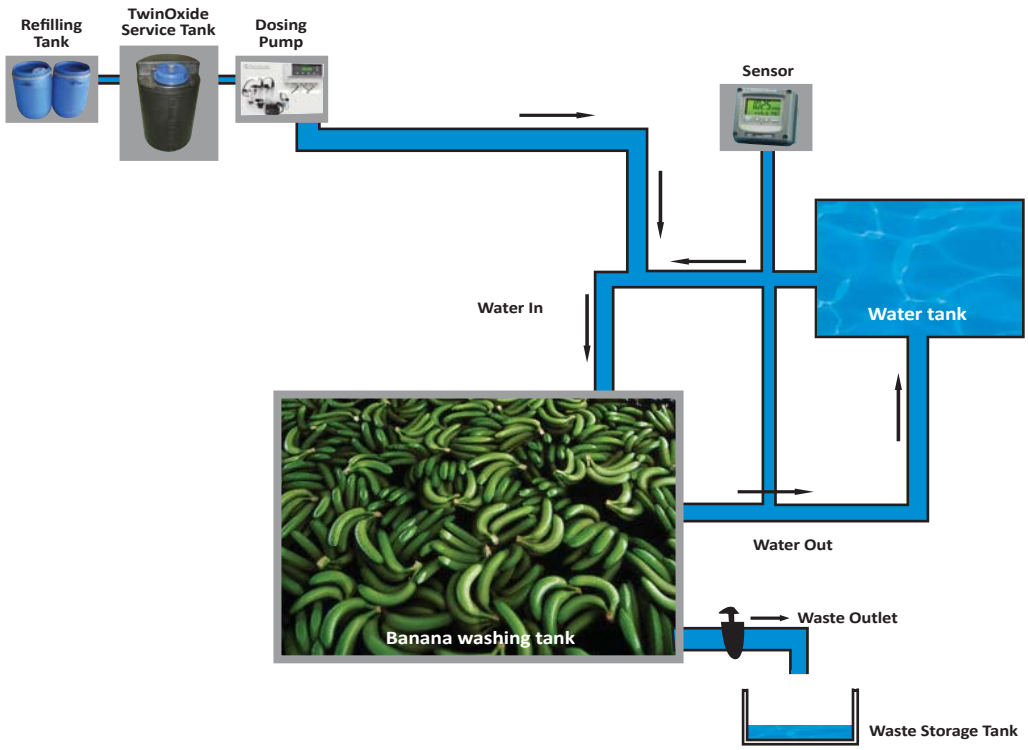
In the flume tank with a capacity of 20,000 liters (approx) and on an average of 8 cycles of water renewal in typical chlorine wash.

TwinOxide® can be of greater utility than any other chemical as not only it will reduce the water renewal cycle by half but will also lead to a marked decrease in the dosage of disinfection chemical into the water.

• The water renewal cycles could be reduced to as low as 3-4 cycles per day, as TwinOxide® has the capacity of greater residual availability in the water.

• The oxidative capacity of TwinOxide® is greater than any chlorine based disinfectant; hence the ppm level of TwinOxide® could be maintained at as low as 8-10 ppm for the initial dosage and as low as 0.8 ppm residual for the continuous dosage depending on contamination this dose can be varied.

• TwinOxide® will be able to operate even at a high pH of 7.5.






## Benefits of chlorine dioxide

- Shelf life increased by factor 3
- Smell problem decreased significantly.
- TwinOxide® is available as 3000 ppm concentrate. Dosage is subject to various factors such as fruit and vegetable type, contamination level, quality of process water and other environmental conditions.

## Cost Comparison

An absolute comparison per volume of other disinfectants does not provide the real cost comparison with TwinOxide®. Other cost factors range from:

- (Chlorine) Reactor cost of ownership, including maintenance, certification & re- certification.
- Security measures & risk and liability insurance policy.
- Training, certification and re-certification of qualified personnel.
- Environmental, health & safety factors.
- Hazard transport cost.
- Use of additional chemicals (e.g. pH level stabilizers).
- The cost of NOT delivering the required biocidal results.

## Summary

TwinOxide® $ClO_2$, which has been developed by experienced scientists, is a very potent biocide while at the same time being stable, reliable & environment friendly. Frequently, systems that require multiple biocides find equal or better microbiological control with just TwinOxide®. TwinOxide® is a specific oxidizer and has little to no reactivity with many products that may be found in the water. It does, however, react with some products readily. These products include many amino acids (sulfur containing amino acids), cyanide, hydrogen sulfide, formaldehyde, iron, manganese and phenolic compounds. This quick reactivity with amino acids, the building blocks of life, is one of the reasons that TwinOxide® is such a strong biocide. Many applications for chlorine dioxide can be found. There is a big list of considerations and applications that make chlorine dioxide interesting to use above the known traditional disinfectants. The list is long and includes treatment for potable water, food, membranes, legionella, algae, biofilm, and process applications, cleaning in place, air treatment etc. Also on the list are issues including synergy with water treatment chemicals, use cost, system performance, environmental impact, selective oxidizer, and wide pH range. One fact many people seem to agree upon is that there are a lot of good reasons to use TwinOxide®.

**1 liter of TwinOxide® 0.3% solution at 0.05 ppm disinfects 60,000 liters of water.**
**1 liter of TwinOxide® 0.3% solution at 3 ppb disinfects up to 1,000,000 liters of water!**

Dr. Mrinal Kanti Ghosh, india@twinoxide.com