Applications of electrolyzed water in Food and Bio-Industry of Taiwan

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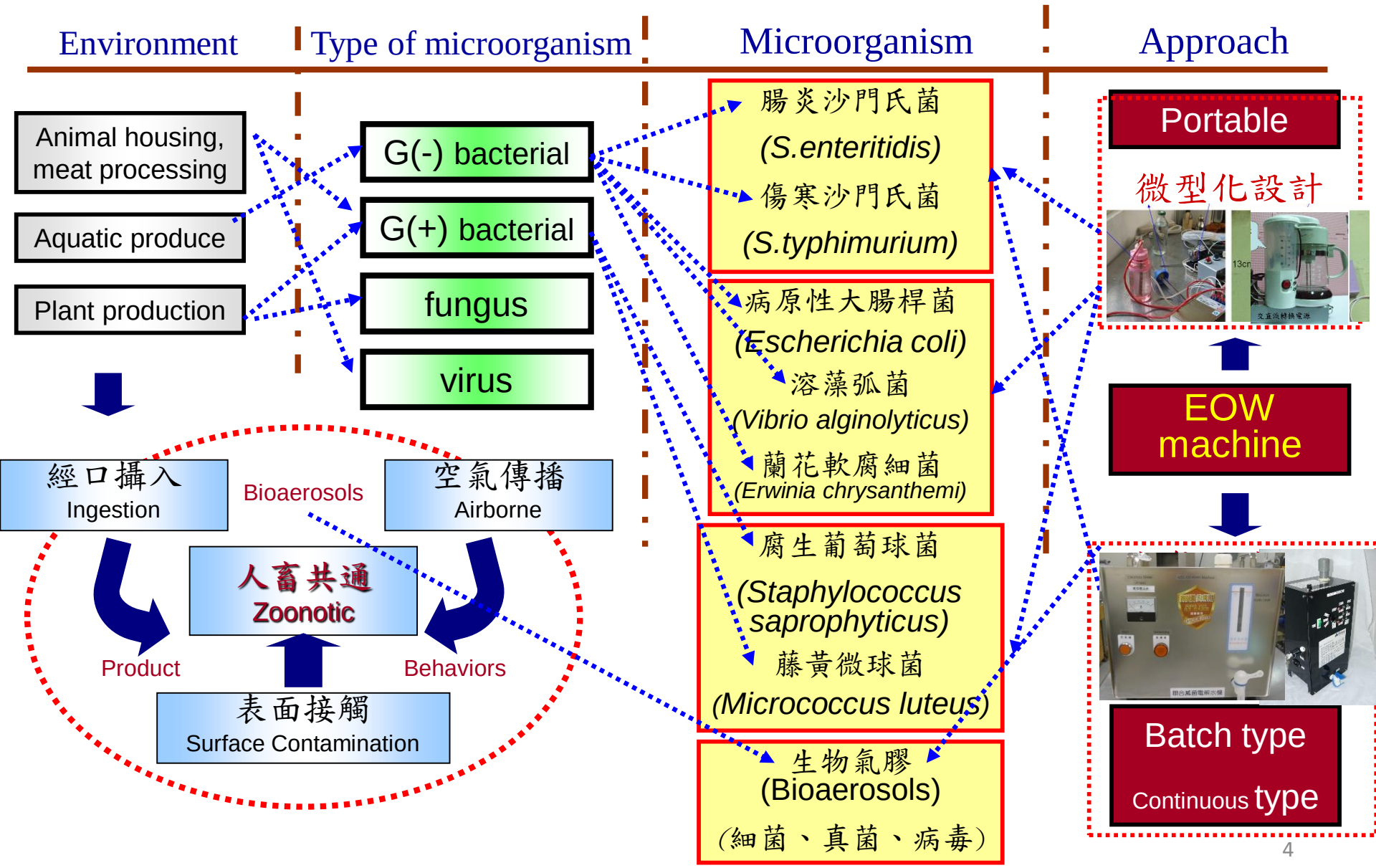
Outline

- About my previous work
- Making of EW
- FDA Top 10 riskiest food
  - Category I: leafy greens, etc. (skip)
  - Category II: eggs
  - Category III: tuna, oyster (skip)
  - Category IV: cheese, ice cream

Electrolyzed water (EW)

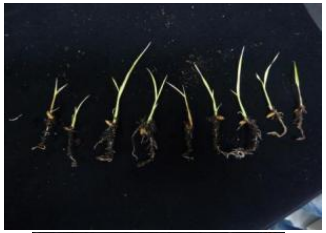
- To be specific, electrolyzed oxidizing water (**EOW**)
- An environmental friendly, safe and powerful **deodorant, disinfectant** and **sanitizer** to kill a variety of fungi, bacteria and virus.

EOW related work on fundamentals and machine design



System installed: Bio-Industry (1)

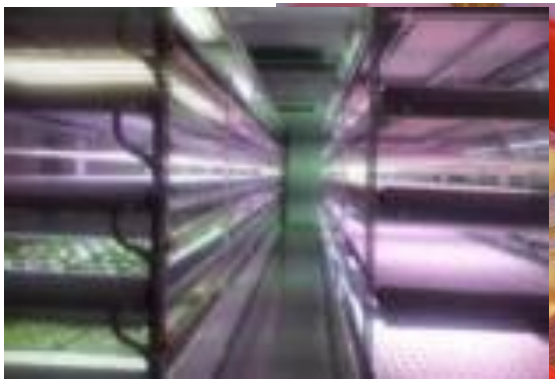
EOW 栽培介質滅菌 steam



Seeds 種子滅菌

Carrot 胡蘿蔔廠
-廠區清潔，生產過程消毒

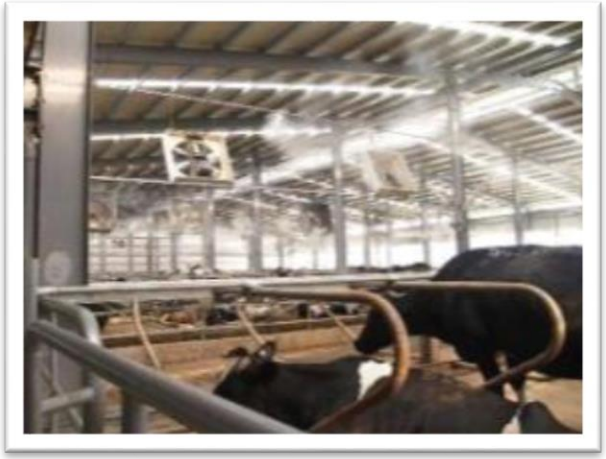
Orchid 蘭花園-介質消毒



Plant factory 植物工廠-
種子、資材消毒、空間消毒

Mushroom farm 養菇場

System installed: Bio-Industry (2)



Cow 牛舍噴灑
去除異味及空間除菌

Pig 養豬廠-原水處理

Hatching farm 種雞場

Zoo 動物園噴灑去除異味

Pig 養豬廠-空間滅菌

Egg 蛋雞場

System installed: food processing industry (1)

Chicken 雞隻表面消毒

Chicken 肉品分切(雞)
-環境與生產線

Pig 肉品加工(豬)-
環境與生產線

Fish 魚體分切
-環境與生產線

Shrimp 櫻花蝦
-環境與生產線

Fish 魚體處理
-環境與生產線

System installed: food processing industry (2)

飲料廠-廠區設備與環境清洗

Food powder 粉狀食品-廠區設備

Vege. Food 素食-廠區設備與生產過程消毒

Noodle 製麵廠-廠區設備環境與生產過程消毒

Biotech Corp. 生技廠-廠區設備環境

Duck blood 鴨血廠

廠區及排水溝清洗去除異味

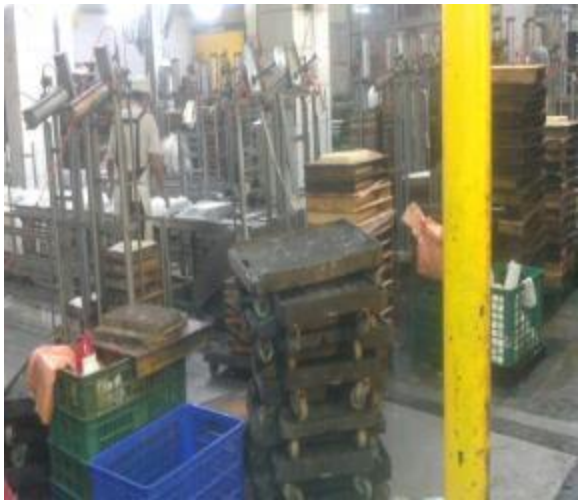
System installed: food processing industry (3)

Sauce factory醬料廠
-廠區清潔，生產線消毒

Soy sauce 醬油廠 – 環境殺菌

Doufu 豆腐工廠: sanitation of wrapping cloth

Restaurant 餐廳人員、器材、環境

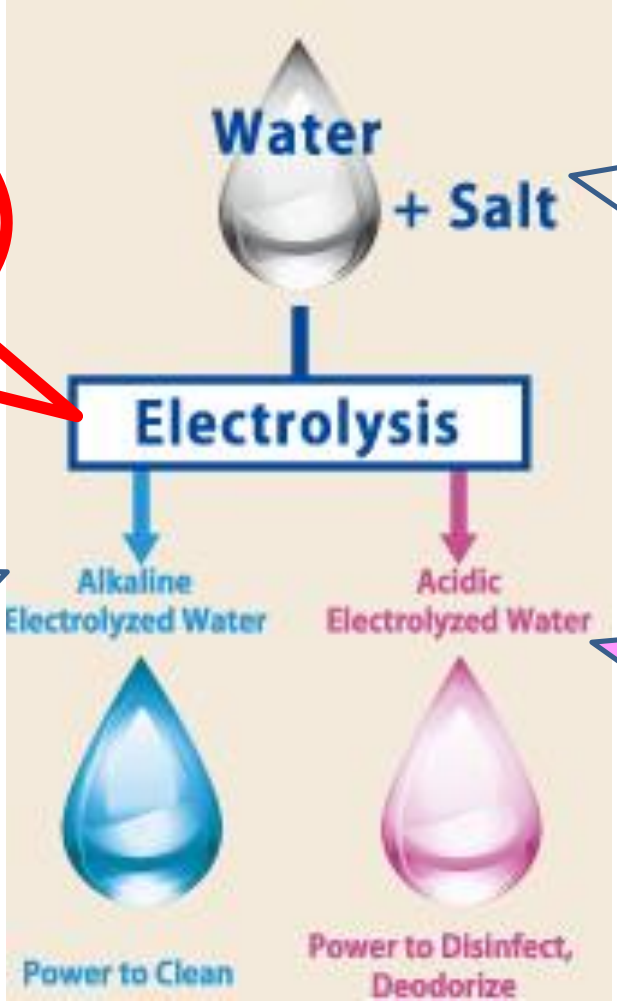


豆腐廠模具滅菌
Containers for dou-fu

大豆浸泡清洗滅菌
Soaking of soy bean

Making of EOW: Method 1

With ion-selective membrane



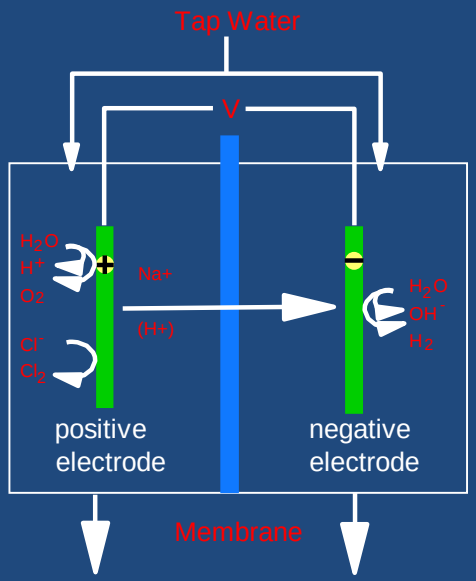
NaCl
KCl
HCl
$CaCl_2$

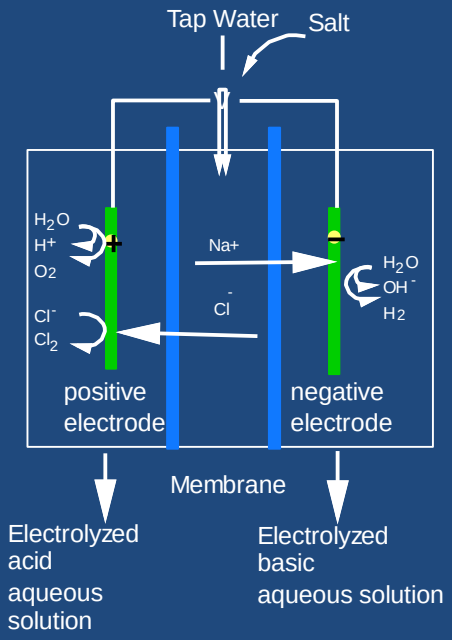
Electrolyzed Reduced Water (dilute NaOH)

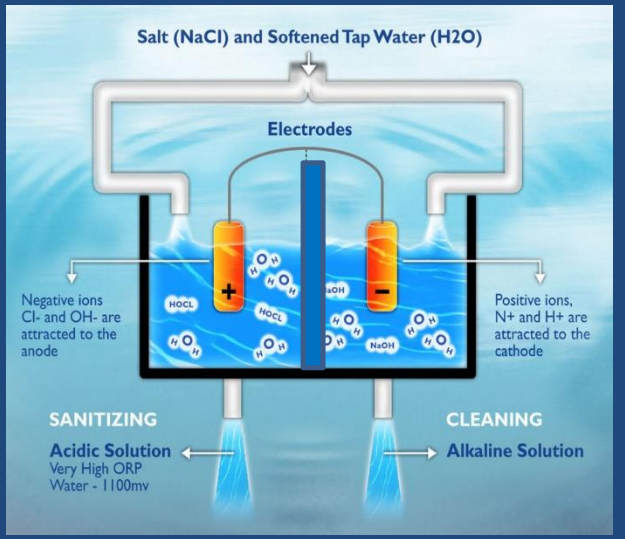
Electrolyzed Oxidizing Water (HOCl, dilute HCl)

ERW or AEW

EOW or AEW


Tap Water
V
H_2O
H^+
O_2
Na+
(H+)
Cl^-
Cl_2
H_2O
OH^-
H_2
positive electrode
negative electrode
Membrane
Electrolyzed acid aqueous solution
Electrolyzed basic aqueous solution


Tap Water
Salt
H_2O
H^+
O_2
Na+
Cl^-
Cl_2
H_2O
OH^-
H_2
positive electrode
negative electrode
Membrane
Electrolyzed acid aqueous solution
Electrolyzed basic aqueous solution

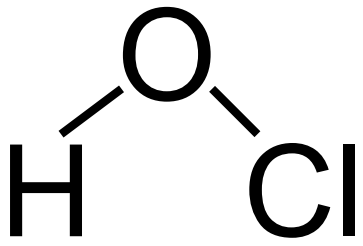

Salt (NaCl) and Softened Tap Water (H2O)
Electrodes
Negative ions Cl- and OH- are attracted to the anode
Positive ions, N+ and H+ are attracted to the cathode
HOCL
NaOH
SANITIZING
Acidic Solution
Very High ORP
Water - 1100mv
CLEANING
Alkaline Solution

Making of EOW: Method 2

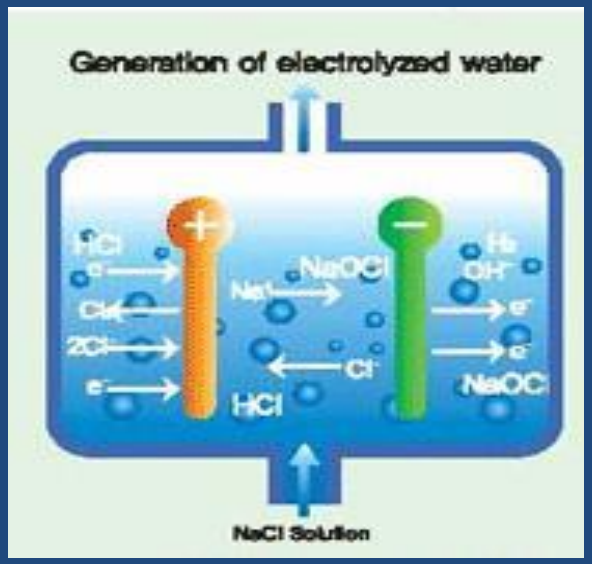
NaCl, KCl, $CaCl_2$ **HCl**

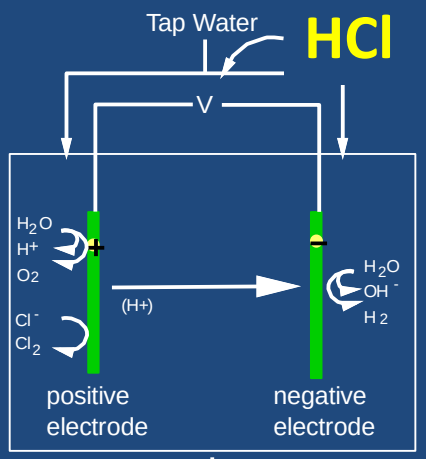
Salty Water → **Electrolysis (membrane-less)** → **EW with HOCl + …**

Without membrane

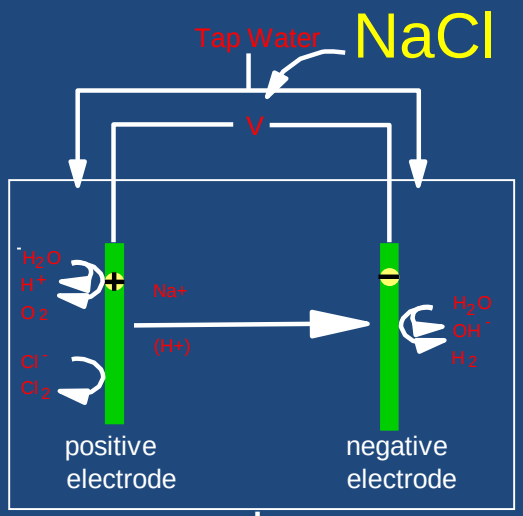


Hypochlorous acid

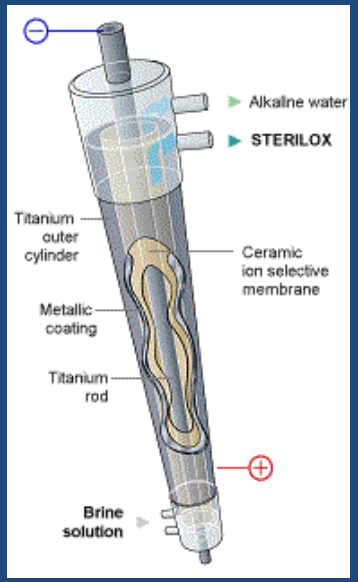




$HOCl + H_2O$



$NaClO + NaCl + H_2O + HOCl$



Sanitizing capability of EW

FAC (Free Active/Available Chlorine)

= AFC (Active/Available Free Chlorine)

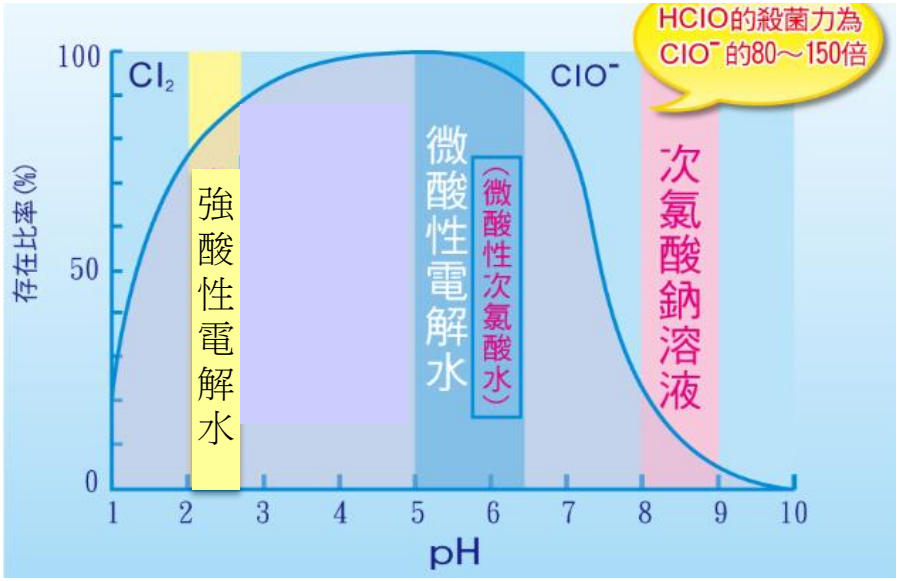
FAC = Concentration of $HOCl + OCl^- + Cl_2$

Sanitizing capability

Cl_2 > HOCl >> OCl^-

pH affect % of HOCl in EOW made by method 2

$$H^+ + OCl^- \rightleftharpoons HOCl$$



pH at 4 ~ 6, concentration of HOCl at its peak

Features of EOW

Safe

- Solute: salt or HCl
- Low chlorine residue, no carcinogen (causing cancer) produced
- Harmless to skin and respiratory tract

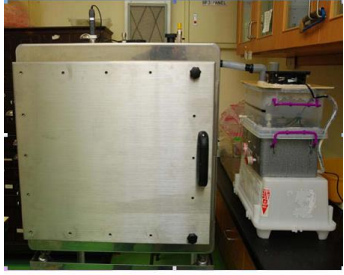
Powerful

- Strong sanitizer, disinfectant
- Strong deodorant
- Long preservation time if sealed and avoid light

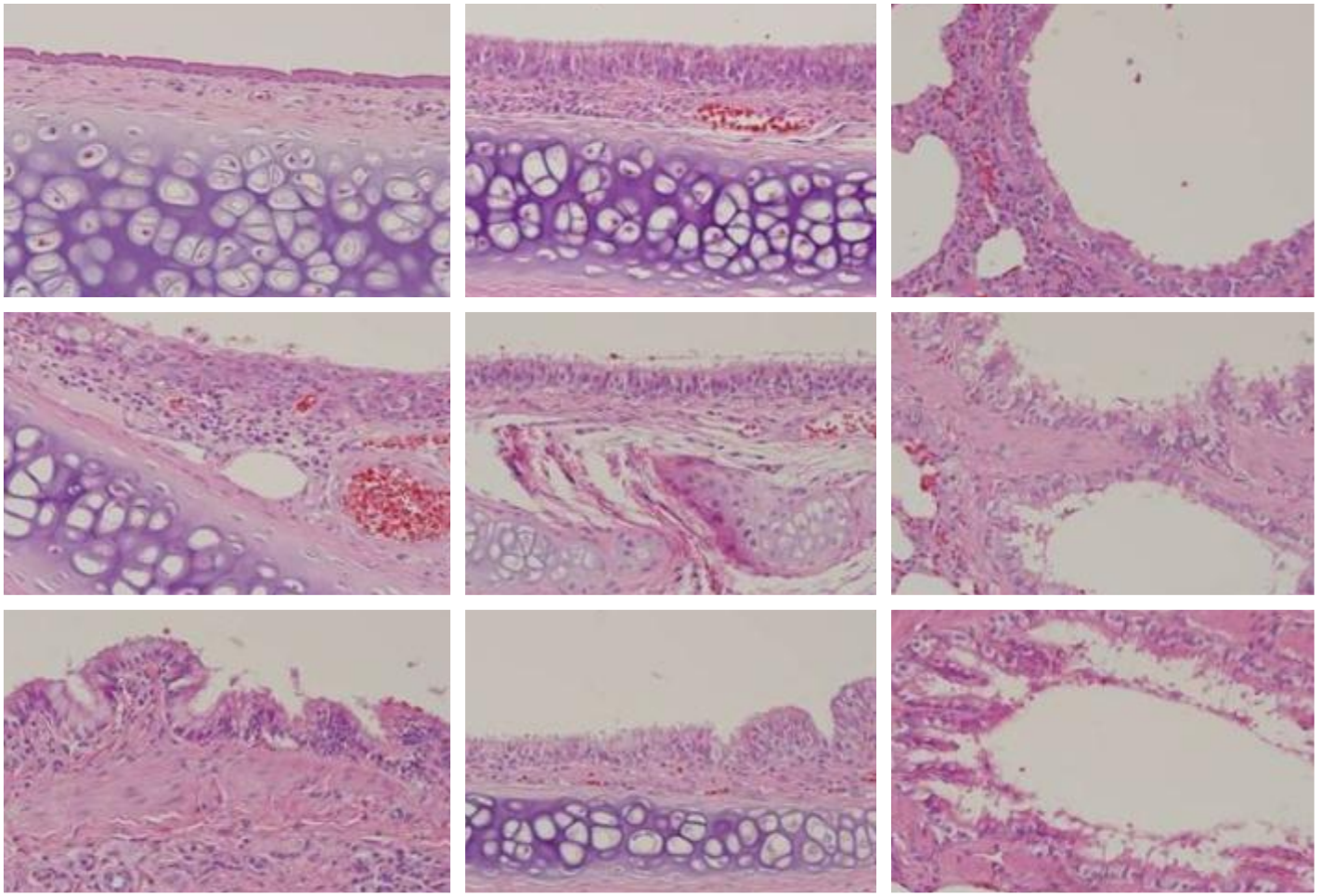
Certified

- Approved for sanitization usage
- Approved to use as food additive: US_FDA, JN mhw 厚生省、 CODEX 國際食品法典, European EPA, TW mhw 衛福部

Lab rat: EOW fog - inhale



鼻黏膜 nasal mucous membrane　氣管 trachea　肺臟支氣管 bronchus



FAC@ 50 ppm 無明顯的傷害

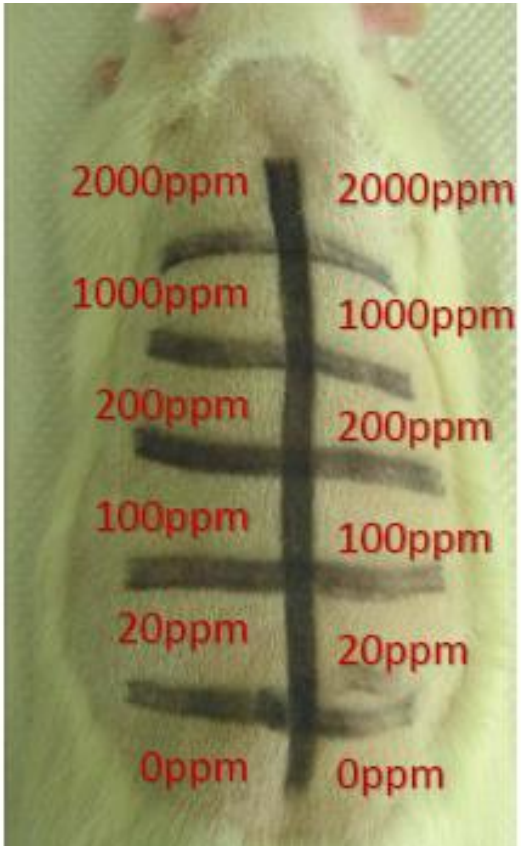
100 ppm 黏膜上皮輕度增生且有分泌物

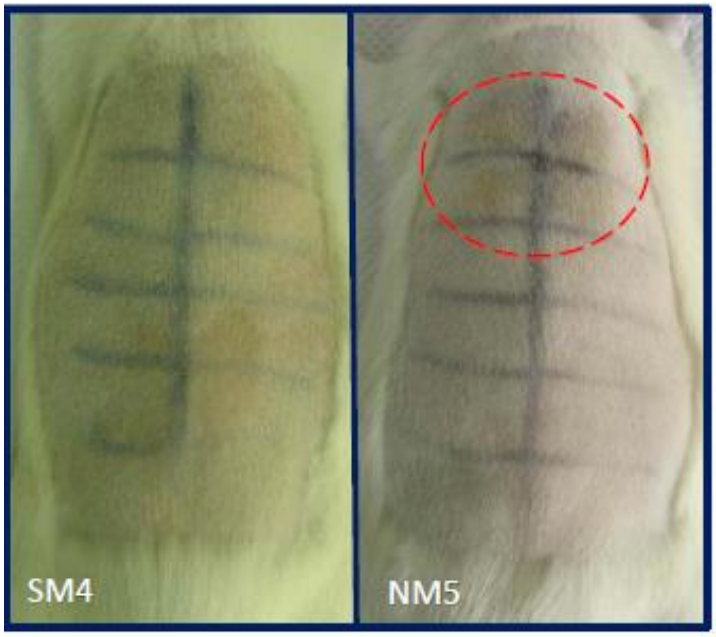
200 ppm 黏膜上皮輕至中度增生且分泌物增加

*臨床病理解釋此為**持續刺激呼吸道所產生之正常症狀，且為可逆現象並非持續性傷害。**

Lab rat: EOW water – skin contact

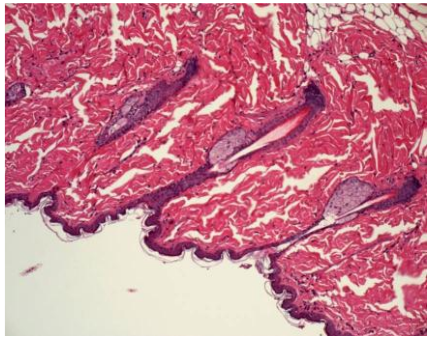
實驗方法：
重覆單次投予的動作三次，在第三次投予後，讓次氯酸水留在皮膚上不擦乾

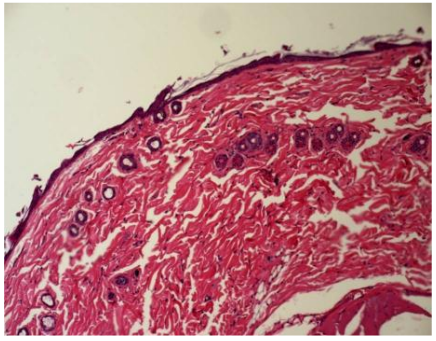


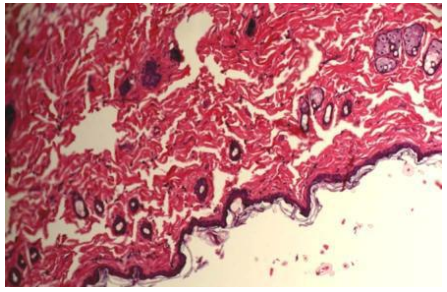


以連續投予的方法，到1000ppm以上才會有顏色變化。(上圖)
以組織切片來看對於皮膚沒有刺激或是有分泌物的現象。(右圖)

FAC@0,200,1000 ppm (top down)







US Regulations

1. Use of EO water as a sanitizing agent is considered a special case of chlorination. Hence EO water can be used in any application while currently chlorine is allowed.
2. In poultry wash tank, 50 mg/L chlorine is allowed.
3. Under Food Codes, food service operations need to used chlorine water with minimal 200 mg/L

EU Regulations

1. Regulation (EC) No 1333/2008 on food additives
    1. Substances not consumed as food itself but used intentionally in the processing of foods, which only remain as residues in the final food and do not have a technological effect in the final product (processing aids), should not be covered by this Regulation
    2. Chlorine and EO water is considered as a processing aid , it needs to be regulated by the positive list in each state member. In the case of Spain, there is not a positive list in which is approved or excluded.
    3. a processing aid, it may result in the unintentional but technically unavoidable presence in the final product of residues of the substance or its derivatives provided they do not present any health risk and do not have any technological effect on the final product"
    4. It is the responsibility of the operator of the food industry, based on the responsibilities of operators of food businesses (EC 178/2002 regulation of the European Parliament and of the Council, particularly in section 4 on general requirements of food legislation).
2. The application of any disinfection technology for fresh-cut in Europe is uncommon except in England, France and Spain where they use mainly chlorine as a gas or bleach and now of chlorine dioxide.

Taiwan Regulations

附表一、用於食品器具容器包裝等食品接觸面之主要消毒成分

NO	CAS 編號	名稱
1	64-19-7	乙酸 Acetic acid
2	98-55-5	松油醇 Alpha-terpineol
3	12125-02-9	氯化銨 Ammonium chloride

●
●
●
●

12	111-76-2	乙二醇丁醚 Ethylene glycol monobutyl ether	無(註 2)
13	7790-92-3	次氯酸 Hypochlorous acid	總有效氯 200 ppm 以下

附表二、用於食品之主要消毒成分

NO	CAS 編號	名稱	殘留濃度(註 1)
1	無	酸化亞氯酸鈉 Acidified sodium chlorite solutions (ASC) (註 2)	總有效氯 1 ppm 以下
2	10049-04-4	二氧化氯 Chlorine dioxide	總有效氯 1 ppm 以下
3	7790-92-3	次氯酸 Hypochlorous acid	總有效氯 1 ppm 以下
4	7681-52-9	次氯酸鈉 Sodium hypochlorite	總有效氯 1 ppm 以下

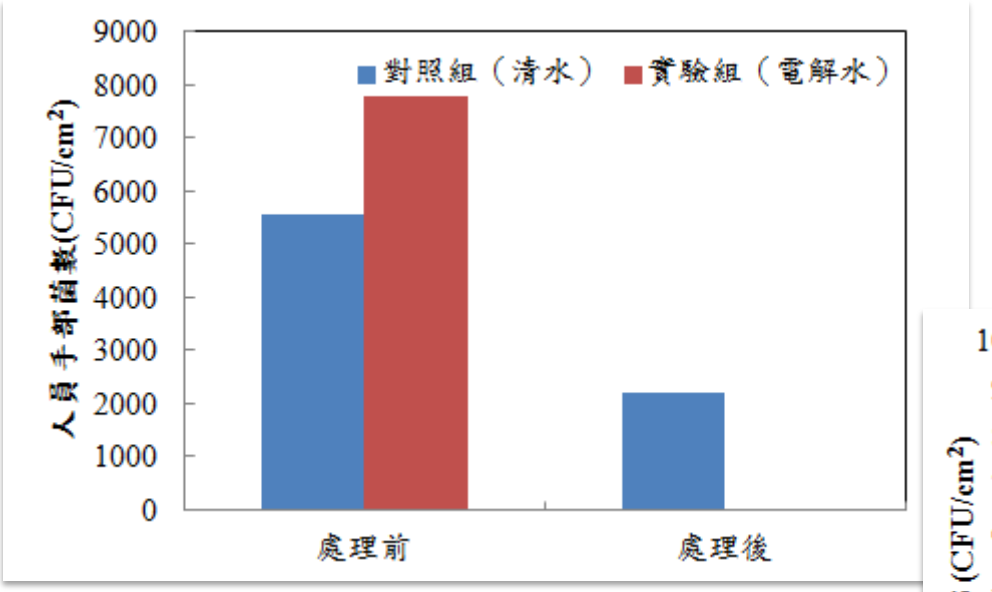
註 1.本表所列成分，使用後須再經飲用水充分清洗、殺菁、加熱或其他適當處理，以使最終食品之殘留濃度符合規定。

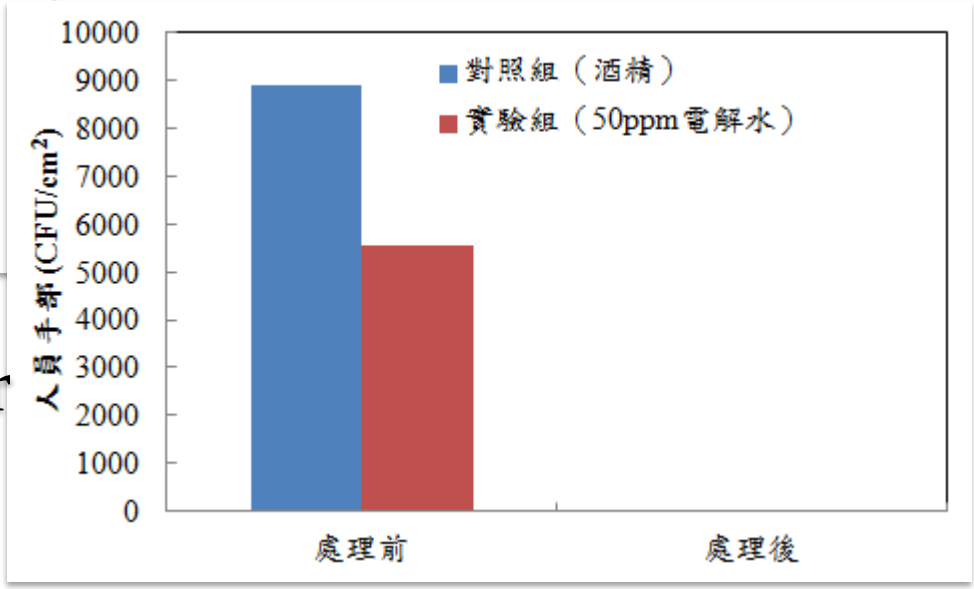
註 2.酸化亞氯酸鈉：由亞氯酸鈉(CAS Reg. No. 7758-19-2)與其他通過 GRAS 認可之酸性溶液調配，pH 介於 2.3-2.9 之範圍。

Food safety concern I

- Sanitation practices:
  Not only food, but also any tool/surface/water/ compartment/personnel need to be sanitized before touching or get contact with the food.

Hands



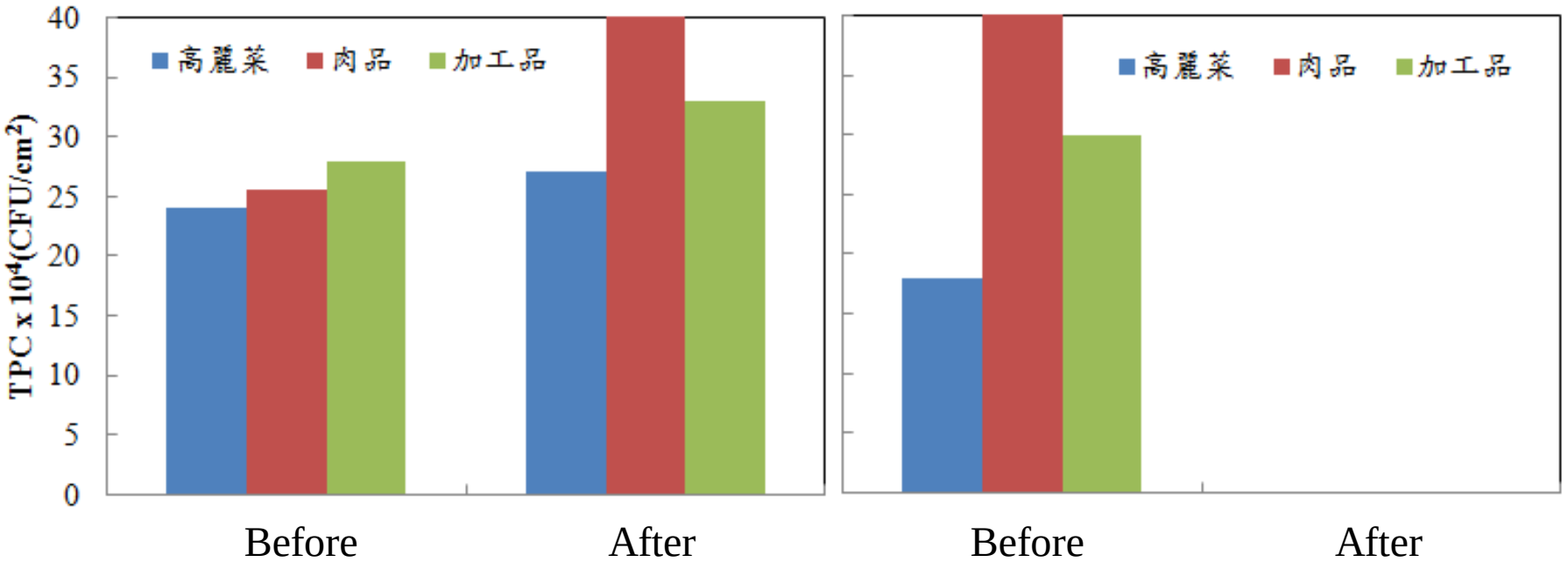


- Wash hands using tap water is not enough
- 50 ppm EOW can be used to replace Alcohol

Cutting board wiped with cleaning rag soaked with tap water vs. 200 ppm EOW

Cleaning rag soaked with tap water

Cleaning rag soaked with 200 ppm EOW for at least 5 min



Cleaning of dish plate

	Bacterial count	Coliform
Plastic dish plate	(CFU/cm^2)	
Untreated	TNTC	TNTC
Tap water treated	5556	0
EOW treated (200 ppm)	0	0
Steel dish plate		
Untreated	11111	2222
Tap water treated	1111	0
EOW treated (200 ppm)	0	0

Now you have clean
hand, cutting board, dishes
but how about air?

Microorganisms associated with an airborne route of exposure that result in adverse human health effects

Microorganism	Health effect	Exposure
Aspergillus fumigatus	Infection, allergy	Mold-contaminated building, compost
Aspergillus versicolor	Allergy toxicosis	Mold-contaminated building
Bacillus anthracis	Anthrax	Bioterrorism, animal habdlers, veterinarians
Chaetomium species	Toxicosis	Mold-contaminated building
Francisella tularensis	Tularemia	Potential WMD, infected rodents
Legionella pneumophila	pneumonia	Aerosols from water spray
Mycobacterium tuberculosis	Tuberculosis	Person-to-Person
Penicullium species	Allergy	Mold-contaminated building
Strachybotrys chartarum	Toxicosis	Mold-contaminated building
Trichoderma species	Allergy, toxicosis	Mold-contaminated building
Variola virus	smallpox	Potential WMD
Yersinia pestis	plague	Potential WMS, infected fleas

Stetzenbach *et al*., 2004

Fungal spore

Food safety concern II

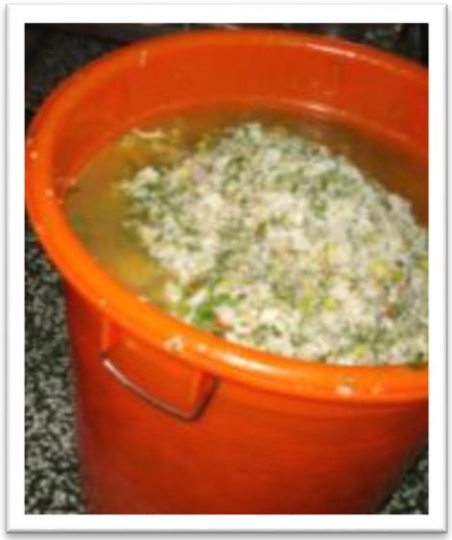
- Not only food, tools/surfaces/water/ compartments/personnel,
  but also the SPACE
  need to be keep clean / sanitized
  before the food entered.

- HEPA Filters, UV, fogging EOW

How about bad smell

Applying EOW for deodorization

EOW in sprayer and use it wherever you need



EOW flooded food waste for sanitation and deodorization

Bad smell around chicken farms can be treated using AKW and ACW

Sources of bad smell:

1. NH_3
2. H_2S
3. ….
4. …..
5. ……

HOCl and NaOH

Bad smell removal rate:

70~98 %

Applying EOW in draining trench

Pour EOW in the draining trench can reduce number of cockroaches, flies, and rats and bad smell.

FDA Top 10 riskiest food

Many of the FDA Top Ten are, unfortunately, some of the healthiest and most popular foods consumed in the U.S. And while some are already considered "high risk" foods, others are surprising. The FDA Top Ten riskiest foods regulated by FDA are:

1. **Leafy Greens: 363 outbreaks involving 13,568 reported cases of illness**
2. **Eggs: 352 outbreaks involving 11,163 reported cases of illness**
3. **Tuna: 268 outbreaks involving 2,341 reported cases of illness**
4. **Oysters: 132 outbreaks involving 3,409 reported cases of illness**
5. **Potatoes: 108 outbreaks involving 3,659 reported cases of illness**
6. **Cheese: 83 outbreaks involving 2,761 reported cases of illness**
7. **Ice Cream: 74 outbreaks involving 2,594 reported cases of illness**
8. **Tomatoes: 31 outbreaks involving 3,292 reported cases of illness**
9. **Sprouts: 31 outbreaks involving 2,022 reported cases of illness**
10. **Berries: 25 outbreaks involving 3,397 reported cases of illness**

fungi, bacteria and virus

http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf

Sources of fungi, bacteria and virus:
from plant itself
from soil and water
from handling personnel, etc.

Many
popu
risk"
are:

gh
FDA

1. **Leafy Greens: 363 outbreaks involving 13,568 reported cases of illness**
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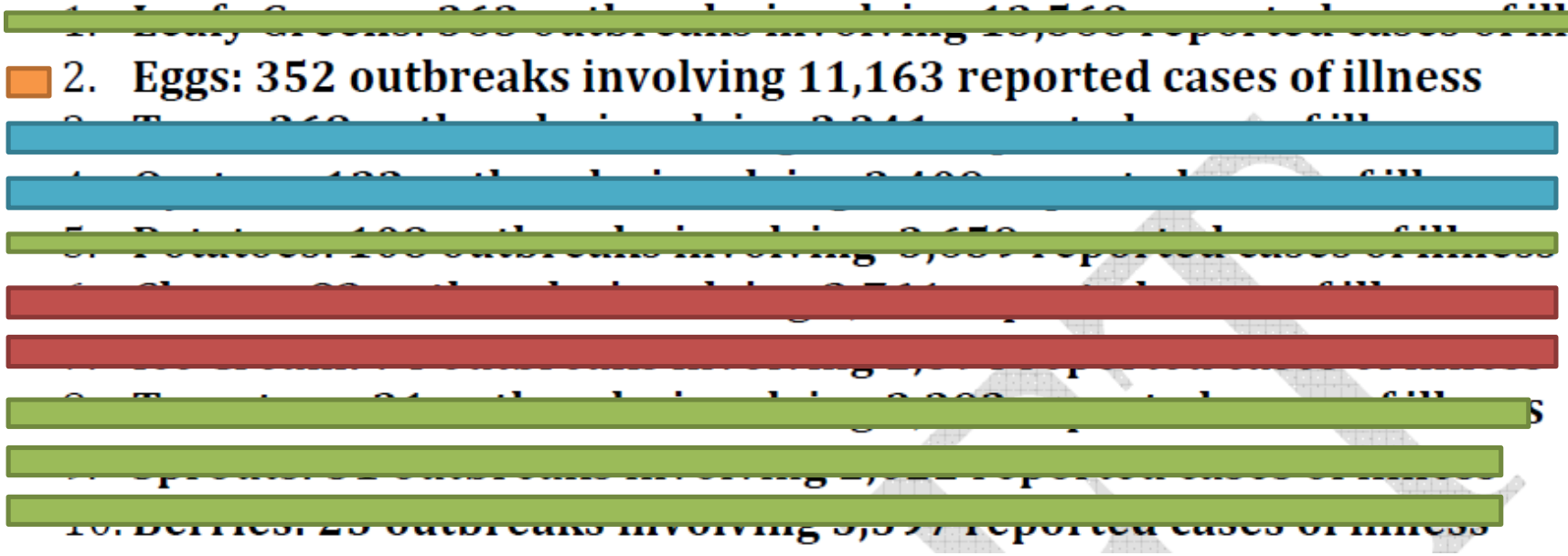
http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf

Sources of fungi, bacteria and virus: from egg shell, contacting surfaces, from handling personnel, etc.

Many popular foods consumed in the U.S. And while some are already considered "high risk" foods, others are surprising. The FDA Top Ten riskiest foods regulated by FDA are:

2. **Eggs: 352 outbreaks involving 11,163 reported cases of illness**



http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf

Poultry

On shell eggs (CFU/cm²)

types / Treatments	Bacterial count (CFU/cm²)	Salmonella (CFU/cm²)	Coliform (CFU/cm²)
Tap water 10 sec soak	TNTC	TNTC	TNTC
100 ppm 10 sec EOW soak	561.7	0	0
200 ppm 10 sec EOW soak	56	0	0
100 ppm 30 sec EOW soak	244	0	0
200 ppm 30 sec EOW soak	189.3	0	0
100 ppm EOW spray	60.7	0	0
200 ppm EOW Spray	10.7	0	0

Due to roughness on the surface of the egg shell ?

Poultry

On shell eggs (log_{10} CFU/shell egg)

Treatment	Time (min)	Reduction	
		L. mono.	*S. Enteriditis*
Deionized water	1	0.25	0.43
	5	0.30	0.85
Alkaline EO water	1	0.59	1.48
	5	0.94	3.13
Acidic EO water (41 ppm)	1	2.55	2.36
	5	3.47	3.50
Chlorine water (45 ppm)	1	2.62	2.27
	5	3.84	3.79
AK+AC	1 + 1	3.99	3.63

Park et al. 2005. J. Food Prot. 68:986-990.

Brush, washing and quality inspection machine

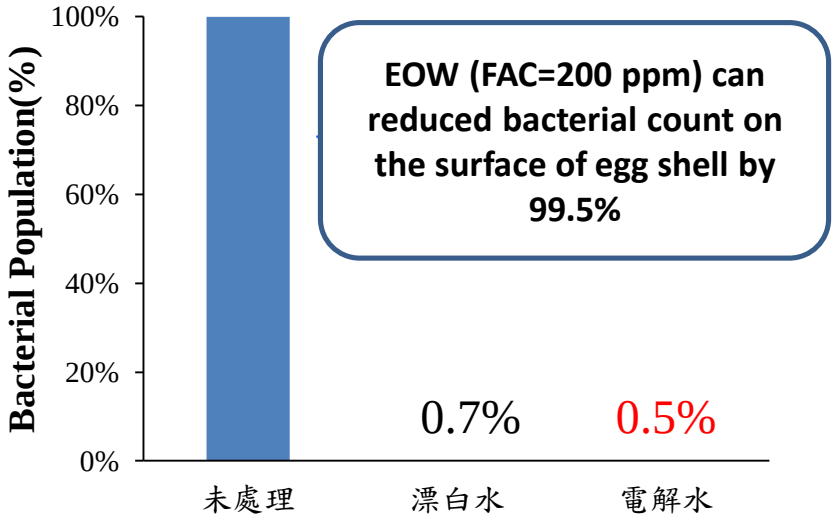
Wash and brush for 20 sec using 55 ℃ warm water added with bleach

CNS 10890

Washing eggs in the brusher



Wash for 20 sec using 55 ℃ warm water with EOW additive

EOW (FAC=200 ppm) can reduced bacterial count on the surface of egg shell by 99.5%

Chlorine residue using bleach：**50-100** ppm

Chlorine residue using EOW：**0.5-1** ppm

Does EOW affect the eating quality of egg?

表 2 不同清洗模式經儲放 6 日後對雞蛋蛋殼厚度、豪氏單位、蛋白指數、蛋黃指數的影響

清洗方式	蛋殼厚度 mm	豪式單位	蛋白指數 %	蛋黃指數 %
新鮮雞蛋	-	65.80 a	1.77 a	37.92 a
未清洗	0.41 a	47.13 b	1.41 a	34.76 b
0 ppm	0.41 a	62.43 a	1.60 a	38.01 a
50 ppm	0.40 a	61.71 a	1.81 a	38.15 a
100 ppm	0.42 a	53.48 ab	1.48 a	37.08 ab
200 ppm	0.42 a	59.57 a	1.71 a	38.02 a
0 ppm+超音波	0.41 a	58.11 a	1.63 a	37.50 ab
50 ppm+超音波	0.42 a	56.60 a	1.69 a	37.40 ab

Means within a column without a common letter are significantly different. ($P<0.05$)

No influence on thickness of egg shell, freshness and eating quality of egg among all treatments (FAC of EOW 0~200 ppm)

FDA Top 10 riskiest food

Many of the FDA Top Ten are, unfortunately, some of the healthiest and most popular foods consumed in the U.S. And while some are already considered "high risk" foods, others are surprising. The FDA Top Ten riskiest foods regulated by FDA are:

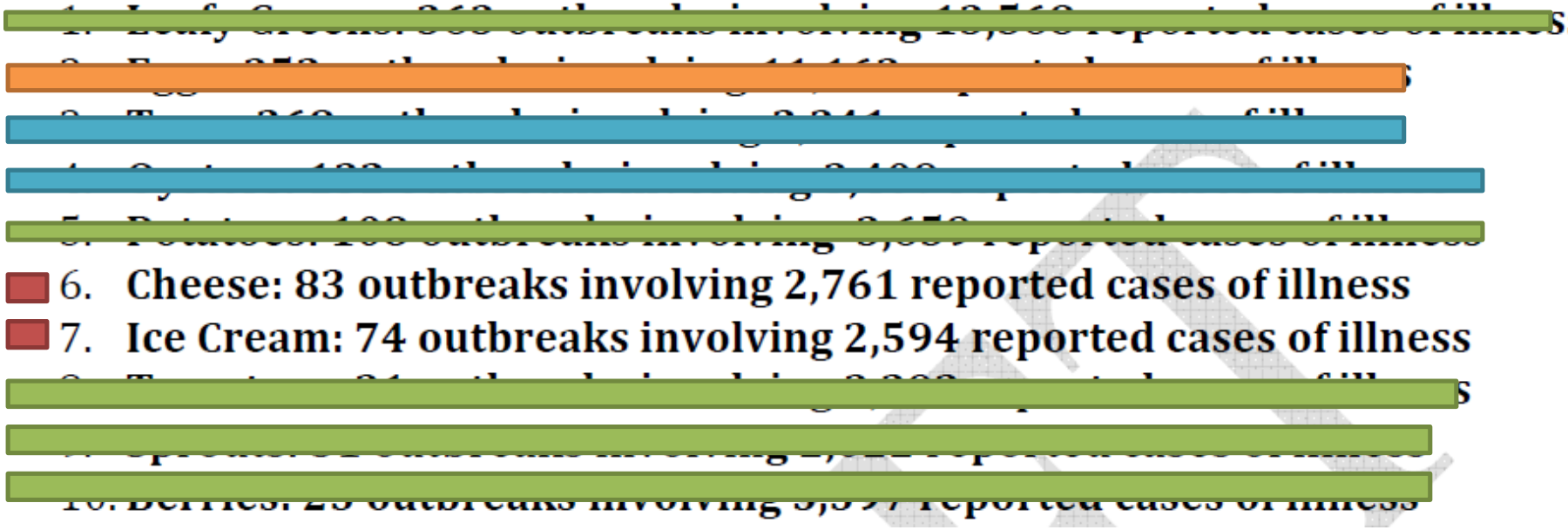
3. **Tuna: 268 outbreaks involving 2,341 reported cases of illness**
4. **Oysters: 132 outbreaks involving 3,409 reported cases of illness**

fungi, bacteria and virus

http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf

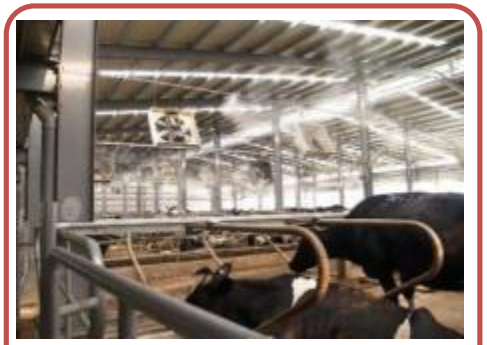
Sources of fungi, bacteria and virus: from dairy produce (milk), from contacting surfaces, from handling personnel, etc.

Many
popu
risk"
are:



6. **Cheese: 83 outbreaks involving 2,761 reported cases of illness**
7. **Ice Cream: 74 outbreaks involving 2,594 reported cases of illness**

http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf



Animal housing

Sanitation: environment

四、防疫資材設備之研發

利用無隔膜電解技術發展高濃度電解消毒水生產設備，目前已證實當無隔膜電解水有效氯濃度達 100 ppm 以上時，即可完全阻斷多種人畜共通菌種之生長（圖 2），在雞舍能持續有效抑菌 2 小時以上，優於市售原白水，證實其應用於農畜禽防疫以及取代市售消毒藥劑之潛力。

Sanitation: water

畜禽舍水質殺菌效能測試

菌數單位 (CFU/mL)	黃使型 鏈球菌	大腸菌群	大腸桿菌群	沙門氏菌	金黃色 葡萄球菌	退伍軍人菌
原水水塔區	5	12	0	0	22	35
水塔進水區	0	0	30	0	0	25
滅菌電解水水塔區	0	0	0	0	0	0
廠內出水區	0	0	0	0	0	0

Deodoring

Applying EOW in poultry/dairy farm at entrance




	Floor	hand	wheel	Car body	shoes
Bacterial reduction %	91.75%	94.90%	94.50%	79.20%	94.90%

Applying EOW in poultry/dairy farm vs. 3 chemicals

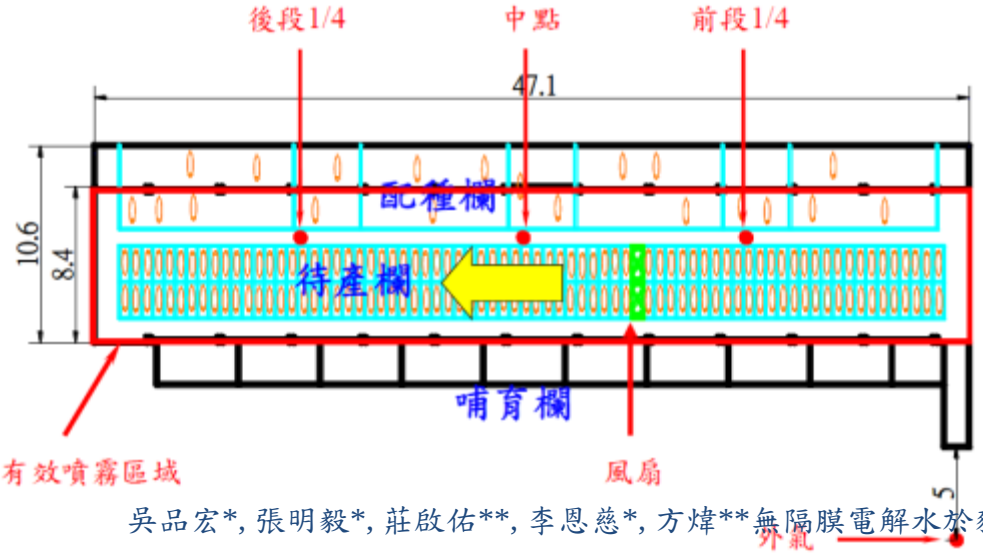
% of bacterial reduced	Air SPACE	Cage	Floor	Chicken
EOW	94.90%	100%	76.60%	100%
百毒殺	79.40%	94.00%	71.60%	92.00%
金碘	33.90%	100%	98.70%	100%
二氯異氰尿酸鈉	94.70%	----	51.70%	89.20%

Air SPACE	10 min	30 min	1 h	3 h
EOW	94.90%	93.00%	66.60%	38.90%
百毒殺	76.70%	12.60%	16%	17.70%

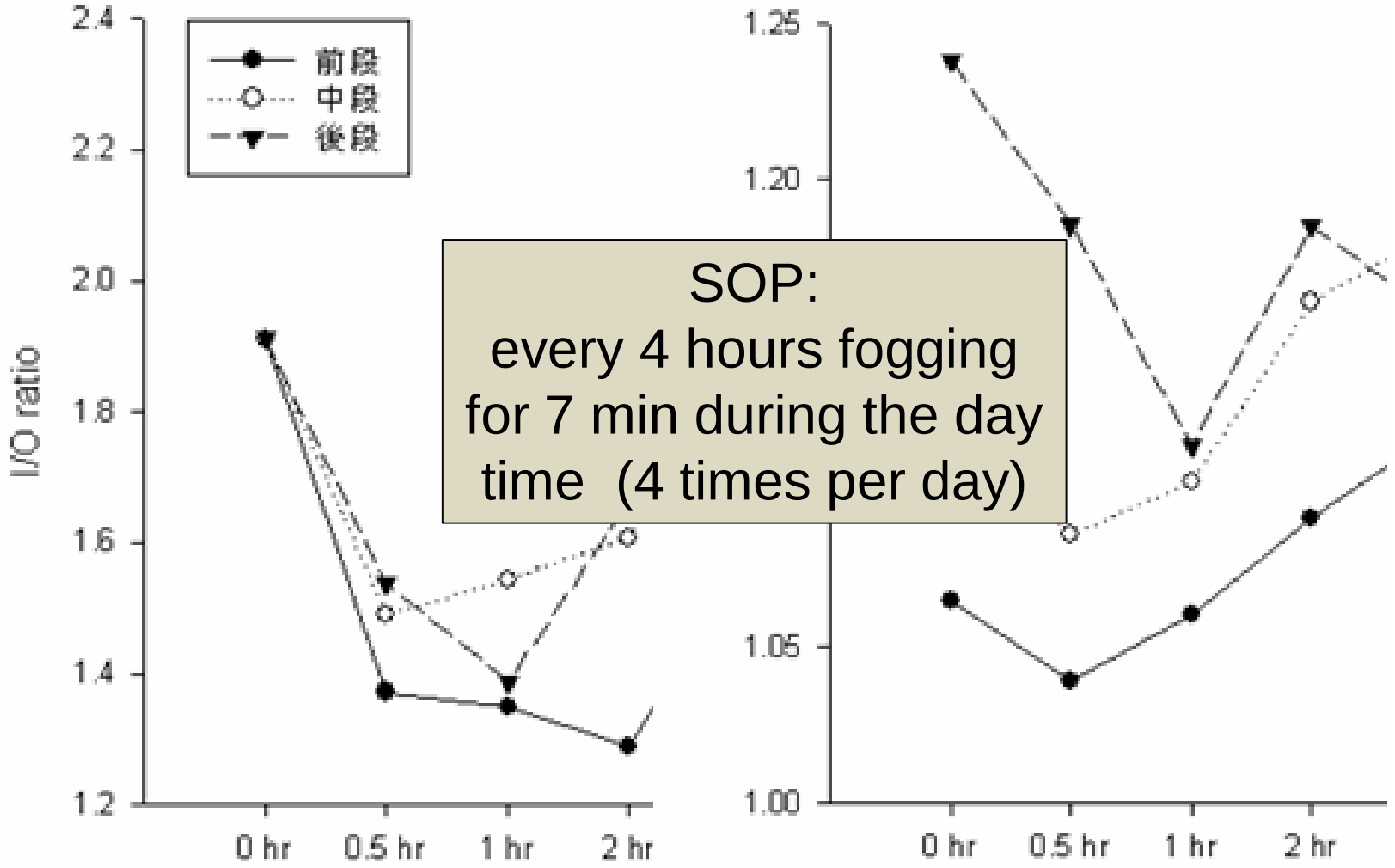
Applying EOW by fogging in an open type pig farm

結合豬舍自有降溫系統即可噴霧電解水，進行大範圍全場消毒殺菌

塑鋼噴嘴：可避免電解水與金屬反應



吳品宏*, 張明毅*, 莊啟佑**, 李恩慈*, 方煒**無隔膜電解水於豬舍空間噴霧消毒之應用,2009



SOP:
every 4 hours fogging
for 7 min during the day
time (4 times per day)

EOW **200 ppm** 空氣中噴霧消毒
(細菌 bacterial)

EOW **200 ppm** 空氣中噴霧消毒
(真菌 fungus)

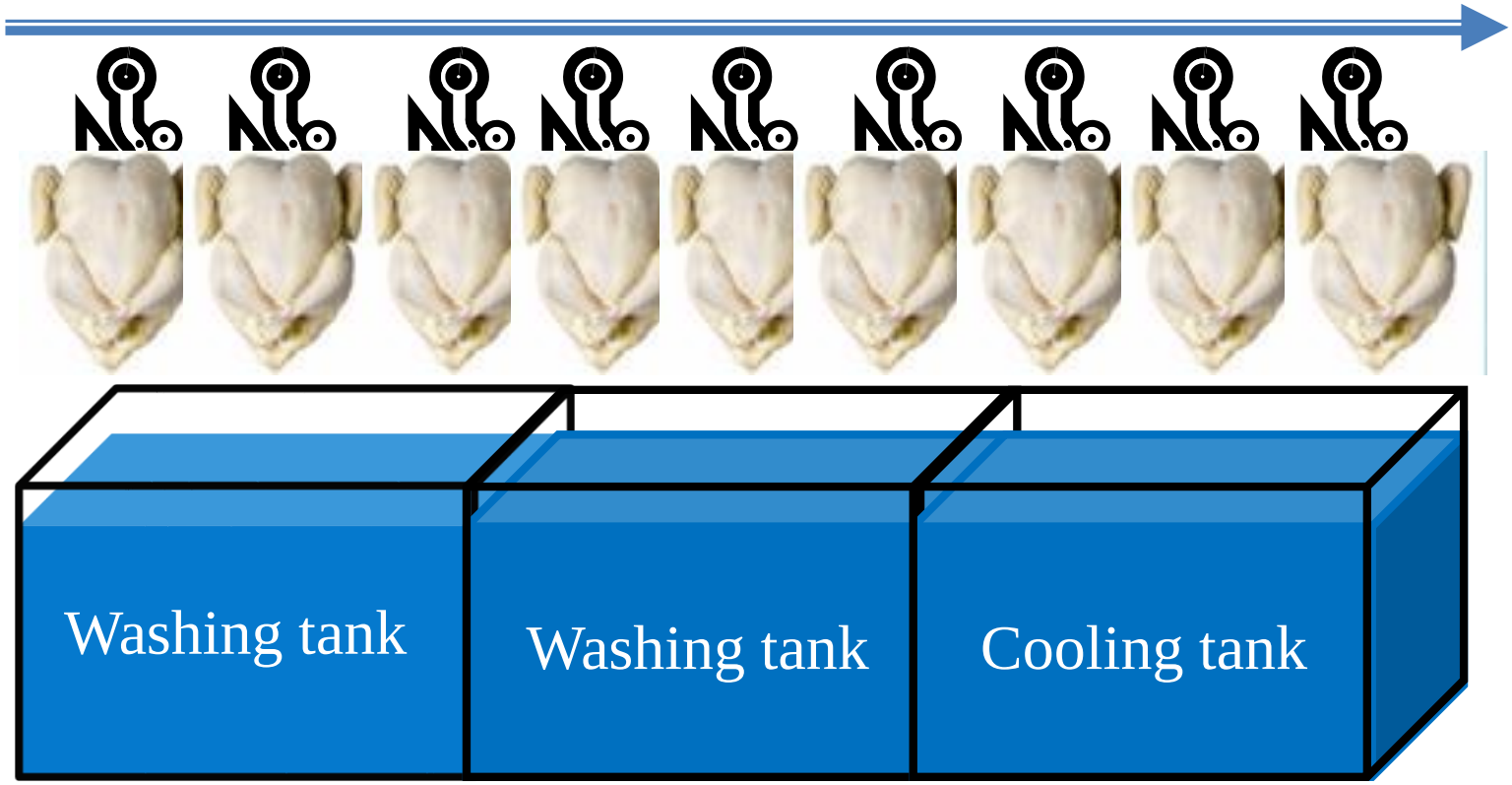
吳品宏*, 張明毅*, 莊啟佑**, 李恩慈*, 方煒**無隔膜電解水於豬舍空間噴霧消毒之應用,2009

Applying EOW in meat industry

slaughtering

Processing

slaughtering



Using 200 ppm EOW (instead of chlorinated water) in **washing and cooling tanks**

- Improve Sanitizing capability
- Greatly reduce bad smell
- Increase safety of employee

Slaughtering factory






Washing and cooling tank

Application Areas in factory

Slaughtering factory - Cooling tank

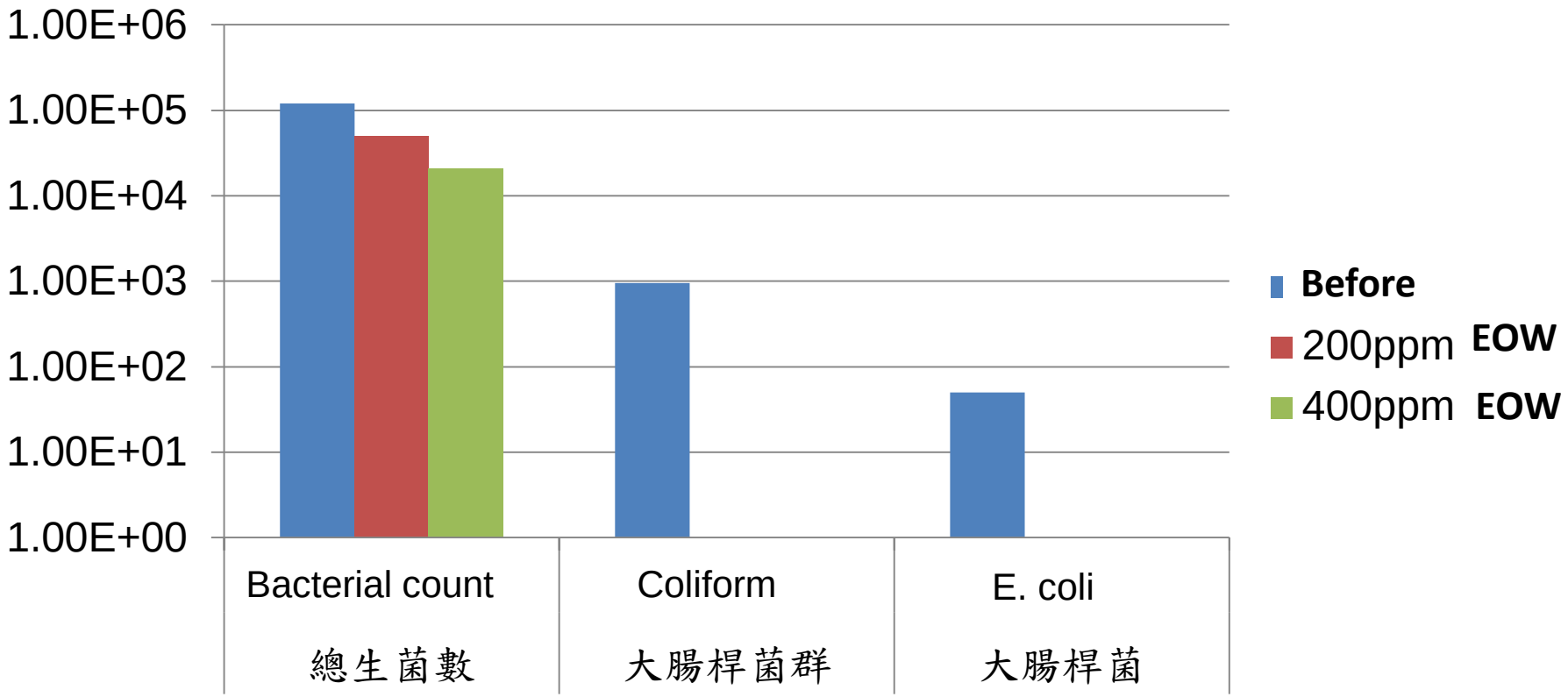
EOW vs. Chlorinated water

Item	Bacterial count	E.coli	Coliform	Treatments
	(CFU/ml)			
whole chicken	6	0	0	Tank #1 **EOW**
	730	0	1	Tank #2 Chlorinated water

Pretreatment: 0.1% peptone water

Sampling in slaughtering factory

Before and after sanitation



Body of chicken, CFU/g	Bacterial count 總生菌數	Coliform 大腸桿菌群	E. coli 大腸桿菌
Before Sanitization	1.2 x 10^5	9.5 x 10^2	5 x 10^1
200 ppm EOW	5.0 x 10^4	**0**	**0**
400 ppm EOW	2.1 x 10^4	**0**	**0**

資料來源：稻江LCC實驗中心

Conclusion

- EOW, a highly cost effective environmental friendly, safe, powerful **disinfectant, sanitizer** and **deodorant**.
- Getting more and more attention scientifically and commercially.
- Can play important role now and beyond.

Sources of fungi, bacteria and virus:
from plant itself
from soil and water
from handling personnel, etc.

Many
popu
risk"
are:

gh
FDA

1. **Leafy Greens: 363 outbreaks involving 13,568 reported cases of illness**
5. **Potatoes: 108 outbreaks involving 3,659 reported cases of illness**
8. **Tomatoes: 31 outbreaks involving 3,292 reported cases of illness**
9. **Sprouts: 31 outbreaks involving 2,022 reported cases of illness**
10. **Berries: 25 outbreaks involving 3,397 reported cases of illness**

http://www.cbsnews.com/htdocs/pdf/FDA_Top_Ten_Report_dangerous_foods.pdf

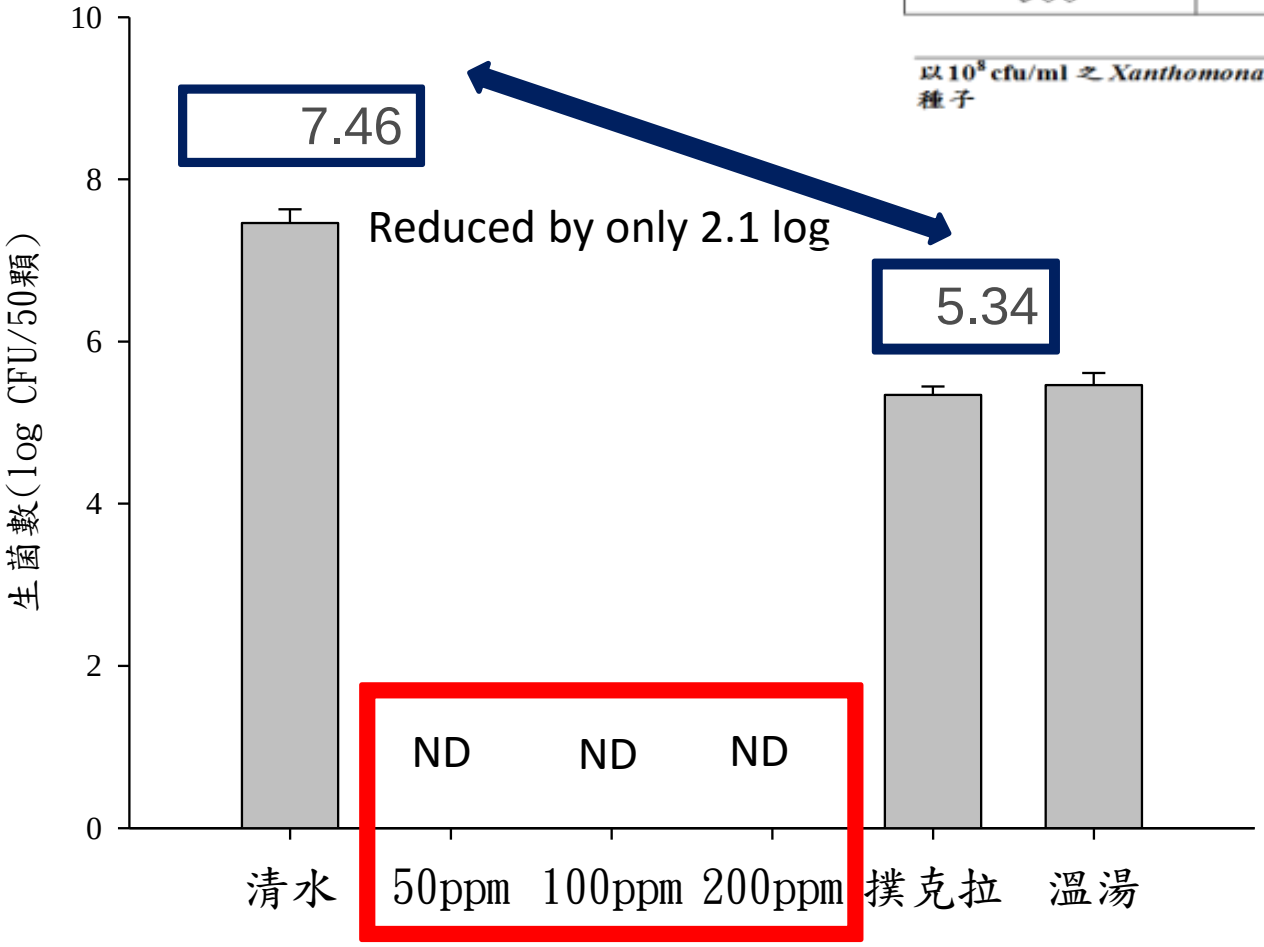
Bacterial related to leafy greens and sprouts

細菌種類	受污染蔬菜種類	References
E. coli O157	苜蓿芽、萵苣	CDC, 1997
Salmonella	苜蓿芽、根莖類	Mahon et al. 1997
Campylobacter	小黃瓜、萵苣	Kirk et al.1997
Shigella	芹菜、萵苣、混合蔬菜	CDC, 1999
Bacillus	芽菜	Portnoy et al., 1976

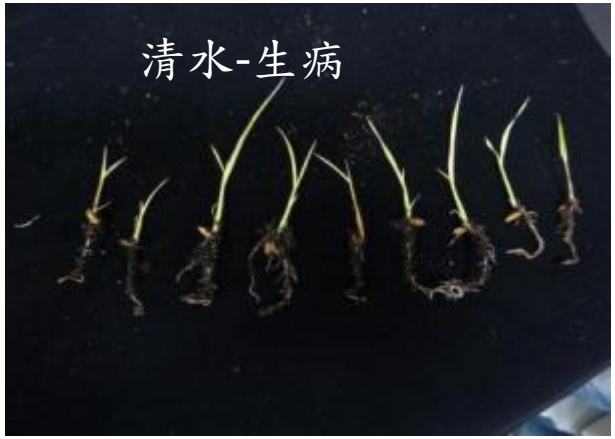
seeds of rice

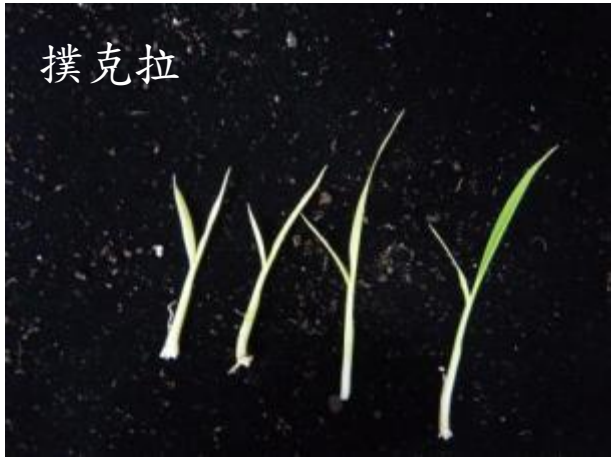
HClO 濃度 (ppm)	處理時間	帶菌率(%)
0	30min	83.5
10	30min	6
50	30min	7.1
100	30min	3.8
200	30min	1.2
500	5min	0

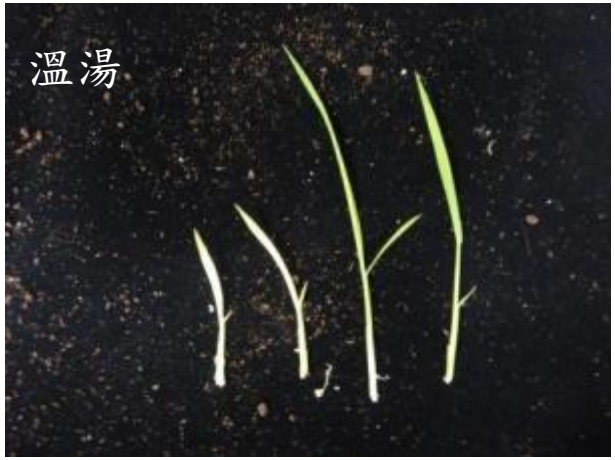
以10^8 cfu/ml 之 *Xanthomonas vesicatoria* 病原菌懸浮液製作帶菌甜椒種子

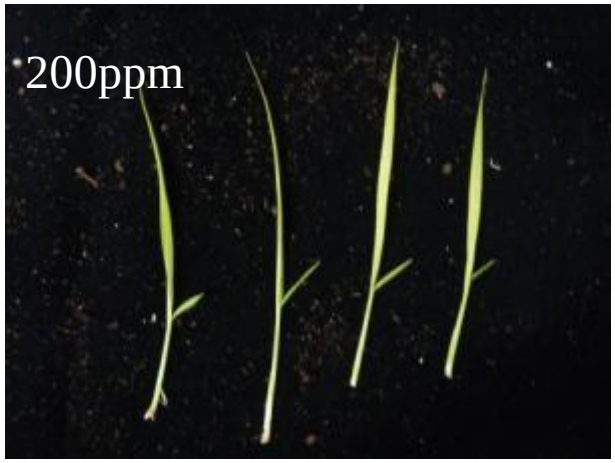


Growth conditions after ‘soaked for 1 hr treatments’









EOW vs. steam treated moss as growth medium

EOW Steam

EOW Steam

EOW Steam

Shelf life

Tap water vs. EOW (500 ppm) **vs. Chlorine Dioxide** (500 ppm)

- DAT (Days after treatment) = 0, 5, 9 at room temperature
- L: tap water, DAT = 5 rot and mold appeared
- DAT = 9, appearance and eating quality: EOW = ClO_2
- EOW is much cheaper than ClO_2

Day 0	DAT = 5, Room Temperature	DAT = 9, Room Temperature
		

L: Tap water, M: EOW 500 ppm, R: ClO_2 500 ppm (**Chlorine Dioxide**)
Soak in water for 5 minutes

Shelf life of Cucumber washed using bleach vs. EOW

Treatment / Days	Bleach (100 ppm)		EOW (100 ppm)	
	Bacterial count (CFU/g)	Coliform (CFU/g)	Bacterial count (CFU/g)	Coliform (CFU/g)
D	--	--	--	--
D+1	270	0	0	0
D+2	450	0	180	0
D+3	450	180	180	0
D+4	540	270	180	0
D+5	2169	270	540	0

Plant factory

Sanitation on personal, tools, cleaning rag, floor, walls, shoes, etc.

A continuous type EOW generating machine was developed

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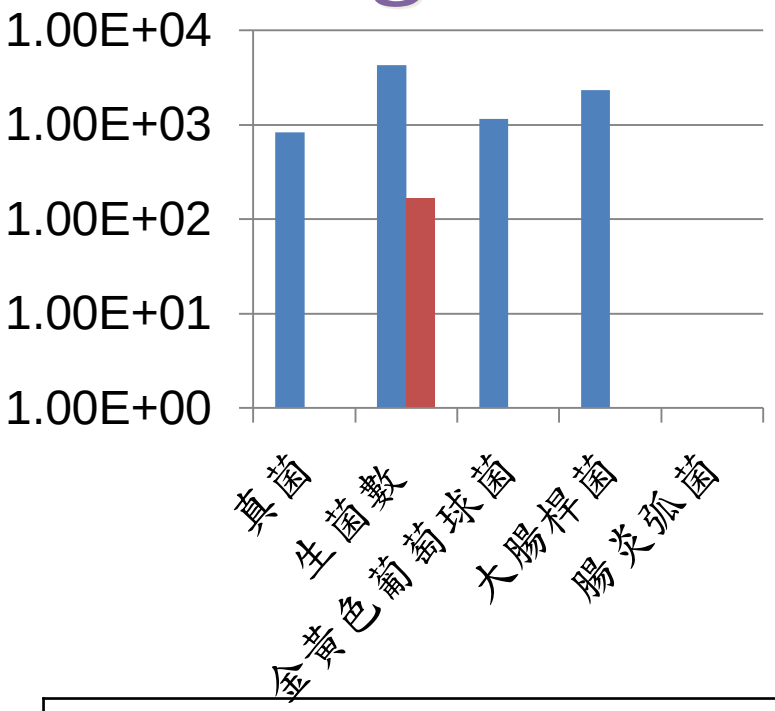
Applying EW in Aquatic produces

- Clams
- Fishes

Soaking of clams in pond vs. EOW



	Pond	EOW 50 ppm (24 hrs)
真菌 fungus	833	0
生菌數 bacterial count	4333	167
金黃色葡萄球菌 *S. Aureus*	1167	0
大腸桿菌 E. Coli	2333	0
腸炎弧菌 *V. Parahaemolyticus*	0	0

資料來源：稻江LCC實驗中心

Sanitizing capability of EOW

LD 100	200 ppm	100 ppm	50 ppm
V.Parahaemolyticus	15 s	15 s	1 min
S. Aureus	1 min	8 min	

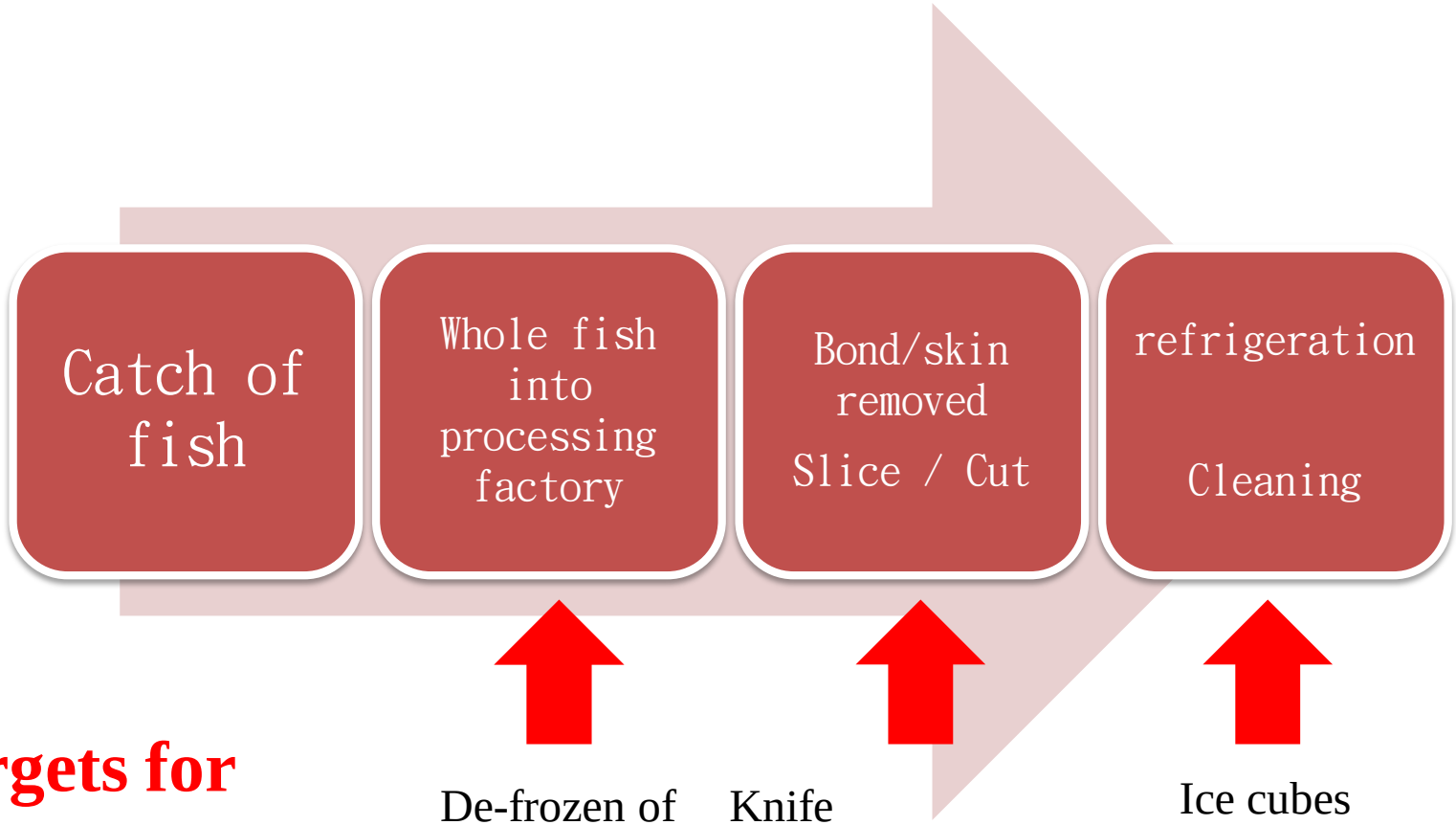
V.Parahaemolyticus 腸炎弧菌是一種嗜鹽性的革蘭氏陰性菌
S. Aureus 金黃色葡萄球菌是革蘭氏陽性菌

Sanitizing capability of EOW vs. Bleach on *V. Parahaemolyticus*

腸炎弧菌

	50 ppm	100 ppm	200 ppm
EW (pH=8)	Reduced 1~2 log	15 s totally killed	Totally killed
Bleach	Reduced 2 log	Reduced 5 log	Totally killed

Applying EW in seafood processing



Targets for EW application

De-frozen of fish

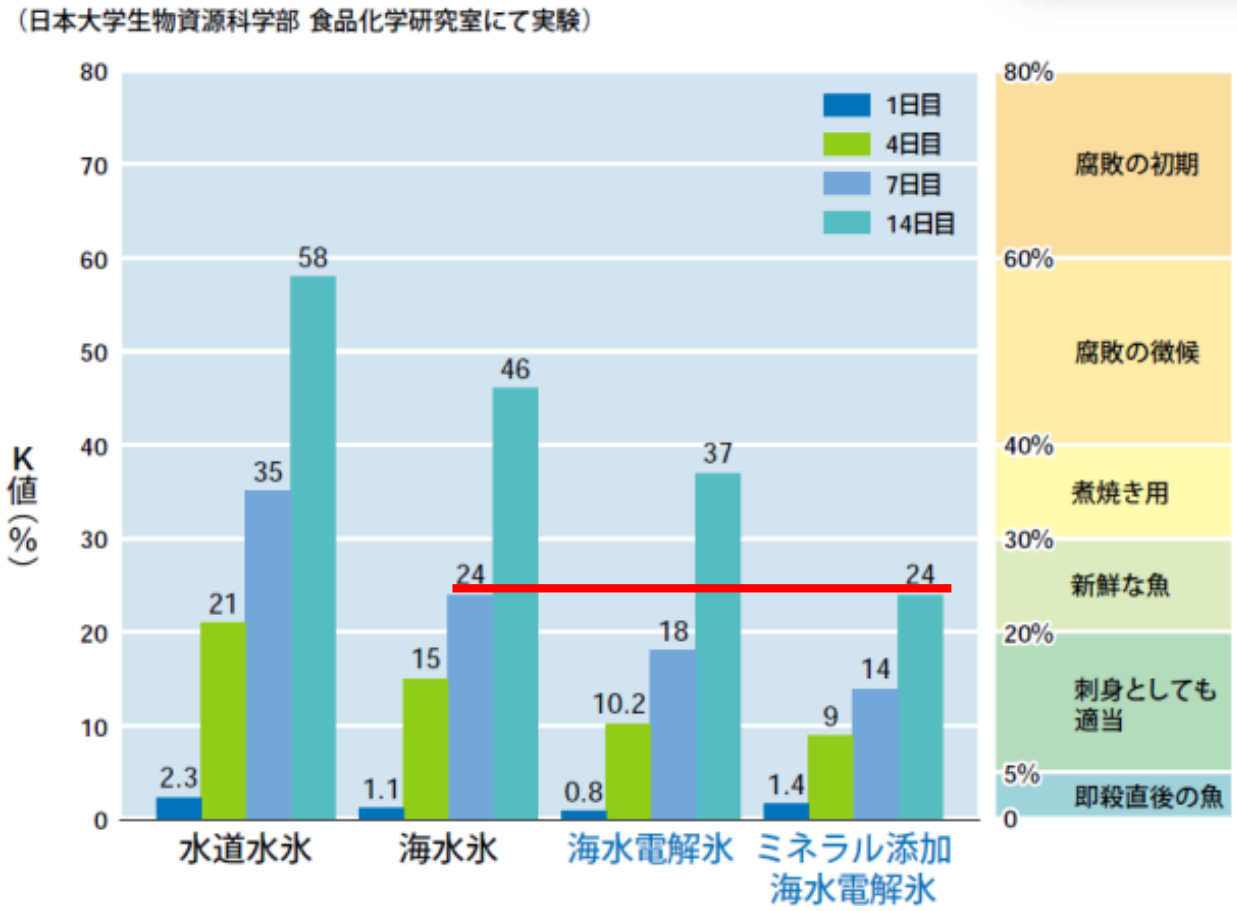
Knife
Cleaning rag
Hands of workers

Ice cubes
Machine
Work bench
Floor
Environment

SOP to apply EOW in seafood processing factory

- Fishbone removing process: flush with EOW lower than 50 ppm
- Leftover waste of Fishbone and meat: soaked in EOW at 200 ppm to remove bad smell.

EOW ice cube



Twice the preservation period

Ice cube made from EOW dissolved slower than ice cube made from tap water,

Temperature drop in fish body using EOW ice cube is faster, thus leading to longer refrigerated shelf life.

Emergia 中國電機製造株式會社