

Ozone in Food & Agriculture

A chemical-free technology

Presented at: CSAE/SCGR-NABEC AIC 2001

University of Guelph

OZOMAX LTD.

By:

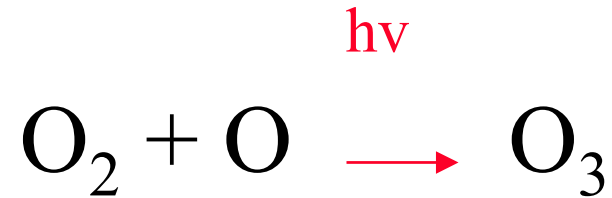
Amir Salama, P.Eng, M.Sc.A .

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- Health & Safety
- Comparison with other disinfectants
- Applications and Effects on Microorganisms
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Ozone

- Gas



- Half-life = 20 -30 min at 20-30 °C.
- 1886: First use for disinfection
- 1907: Nice, Municipal Water Treatment

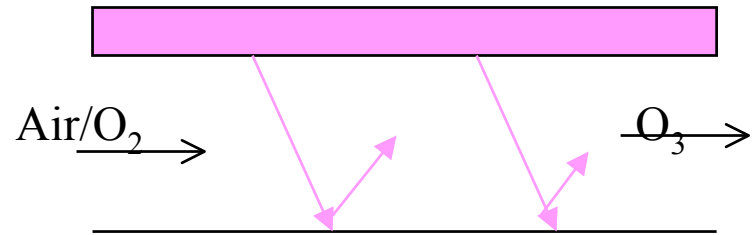
Reactivity

| Oxidant | Redox (V) |
|------------------------|-----------|
| OH^- | 2.80 |
| O | 2.42 |
| O_3 | 2.07 |
| HOCl | 1.49 |
| Cl_2 | 1.36 |
| H_2O_2 | 0.87 |
| O_2 | 0.40 |

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Ozone Production

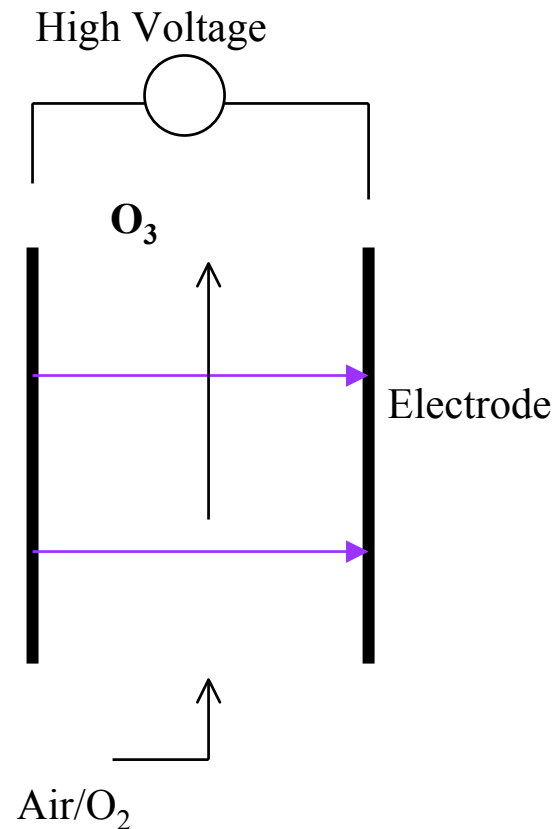
- UV Lamp
 - Ave. ozone production/
UV lamp
 - 0.1 wt%



Ozone Production

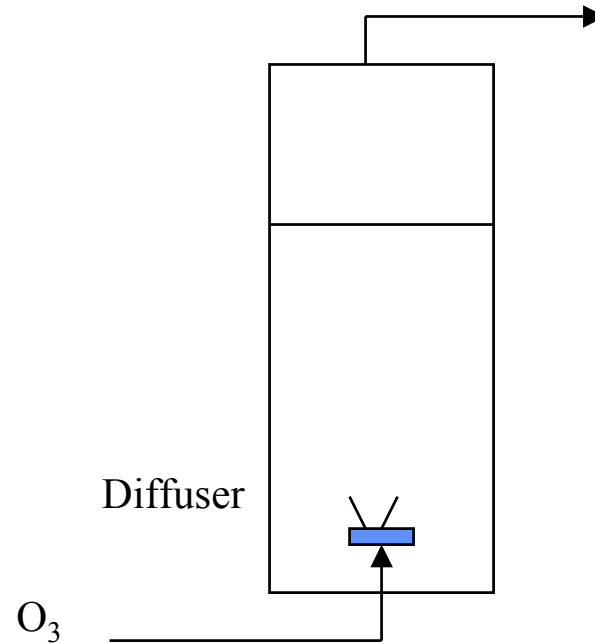
- Corona Discharge
 - Ave. Ozone production
 - 0 - 10 wt%
 - Typical Energy Consumption
 - 20 kWh/kg O₃ with air (LF)
 - 10 kWh/kg O₃ with O₂ (LF)

 - 10 kWh/kg O₃ with air (HF)
 - 5 kWh/kg O₃ with O₂ (HF)



Injection Methods

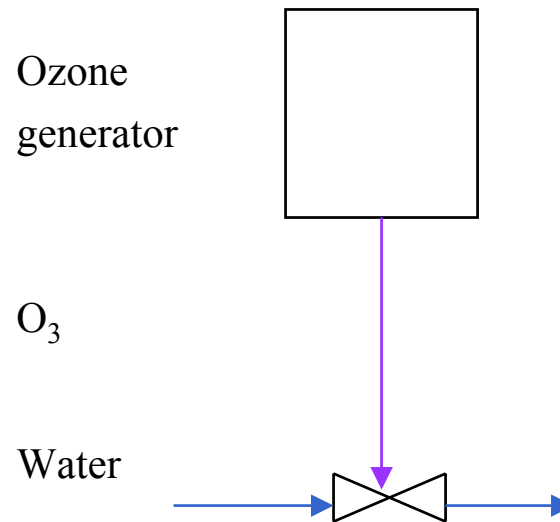
- Contact Column
 - Efficiency
 - 70% ozone dissolution



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Injection Methods

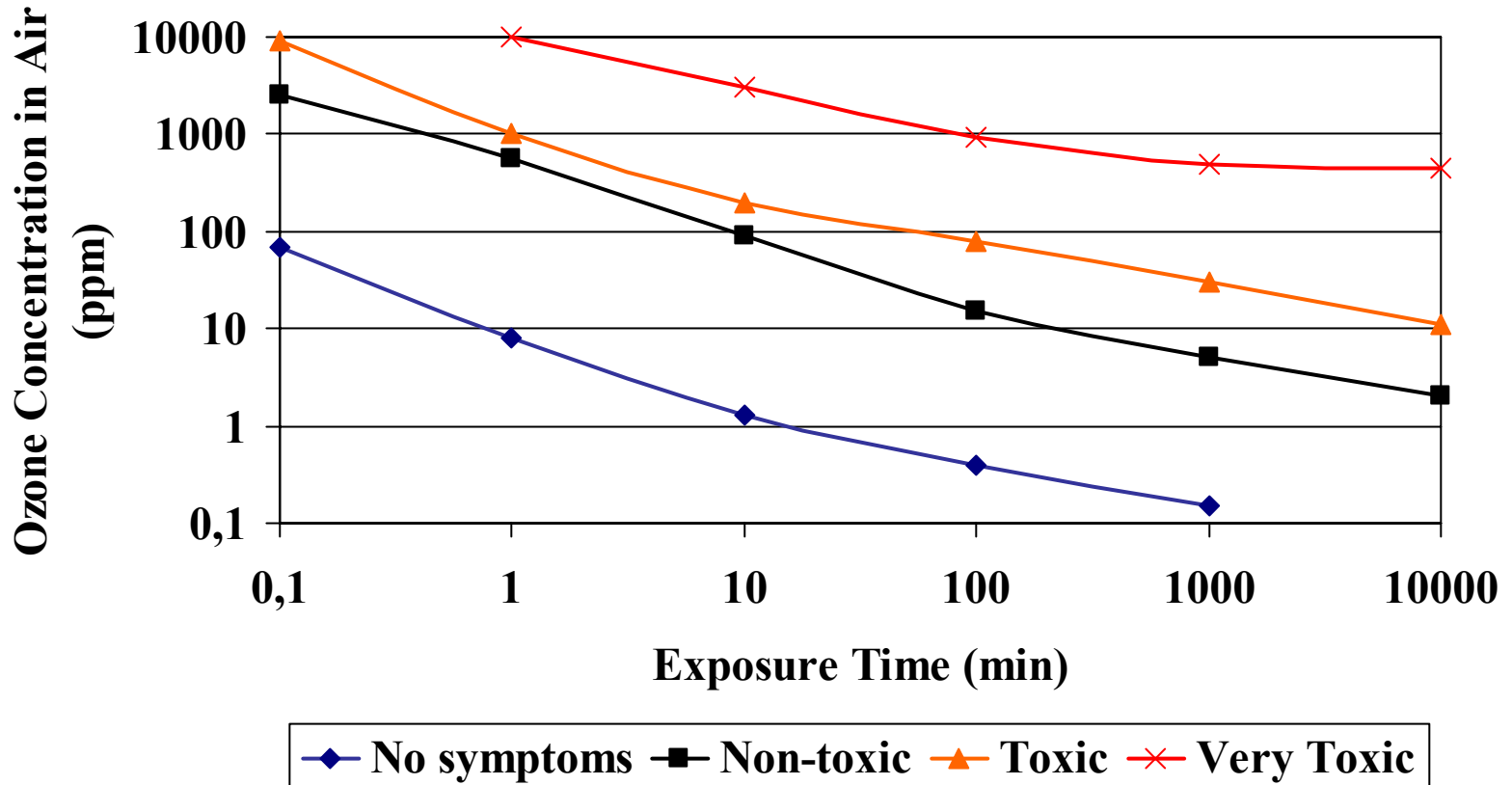
- Venturi
 - Efficiency
 - 90% ozone dissolution



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Ozone Toxicity For Humans

Ref: Perry, Chemical Engineering, Mai 1993



Protection from Exposure

- **Adsorption** $2 \text{ O}_3 + \text{C.A/Al} \rightarrow 3 \text{ O}_2$
 - Activated Carbon
 - Activated Alumina
- **Destruction** $2 \text{ O}_3 + \text{Energy} \rightarrow 3 \text{ O}_2$
 - Thermal
 - UV (254 nm)

Biological Lethal Coefficients of Common Disinfectants

Ref: Hamil et Clawson, Water Technology, Avril 1997

| Disinfectant | Entero-bacteria | Virus | Bacterial Spores | Amoebic Cysts |
|-------------------------|-----------------|--------|------------------|---------------|
| O₃ | 500 | 5 | 2 | 0.5 |
| HOCl | 20 | 1 | 0.05 | 0.05 |
| OCl⁻ | 0.2 | <0.02 | <0.0005 | 0.0005 |
| NH₂Cl | 0.1 | 0.0005 | 0.001 | 0.02 |

BLC : high value = high disinfection power

CT for Common Disinfectants

(pH = 6 - 9)

Ref: Hamil et Clawson, Water Technology, Avril 1997

| Micro-organisms | Free Chlorine Chloramine NH ₂ Cl | Chlorine Dioxide ClO ₂ | Ozone O ₃ |
|-----------------------------|---|---|-------------------------|
| E.Coli | 0.034 – 0.05 | 0.4-0.75 | 0.02 |
| Rotavirus | 0.01 – 0.05 | 0.2 – 2.1 | 0.006 – 0.06 |
| G. lamblia cysts | 47 – 150 | — | 0.5 – 0.6 |
| G. muris cysts | 30 – 630 | 7.2 – 18.5 | 1.8 – 2.0 |

* CT = Conc. O₃ (ppm) x Contact Time (min)

* Established by EPA, 99.9% neutralisation of micro-organisms

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Ozone Applications (Water)

Rules of Thumb

| Application | Conc. O₃ (ppm) | Contact Time (min) |
|-----------------------------------|--------------------------------------|-------------------------------|
| Reverse Osmosis Water | 0.3 - 0.5 | 4 -5 |
| Seafood Wash | 0.1 – 1.0 | 1-2 |
| Fruit & vegetable wash | 0.2 – 2.0 | 1-5 |
| Hydroponic | 0.1 – 0.2 | 2-5 |
| Cooling Tower | 0.2 – 0.5 | 2-5 |
| Chicken & Beef wash | 0.3 – 3.0 | 2-5 |

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Ozone Applications (Air)

| Contaminant | Applications | Conc. O ₃ |
|--|--------------------------------|----------------------|
| Bacteria - <i>Rhizoctonia Solani</i> - <i>Phytophthora Solani</i> | Meat | 0.1-1.5 ppm |
| Fungus & bacteria | Potatoes and vegetable storage | 0.05 - 0.15 ppm |
| Spores | Cheese | 0.02 ppm |
| Salmonella | Eggs | 0.1 ppm |
| Mold | Starch, flour, straw, grains | 0.05 ppm* |
| Fats & Grease | Cotton, wool | 0.05 ppm** |

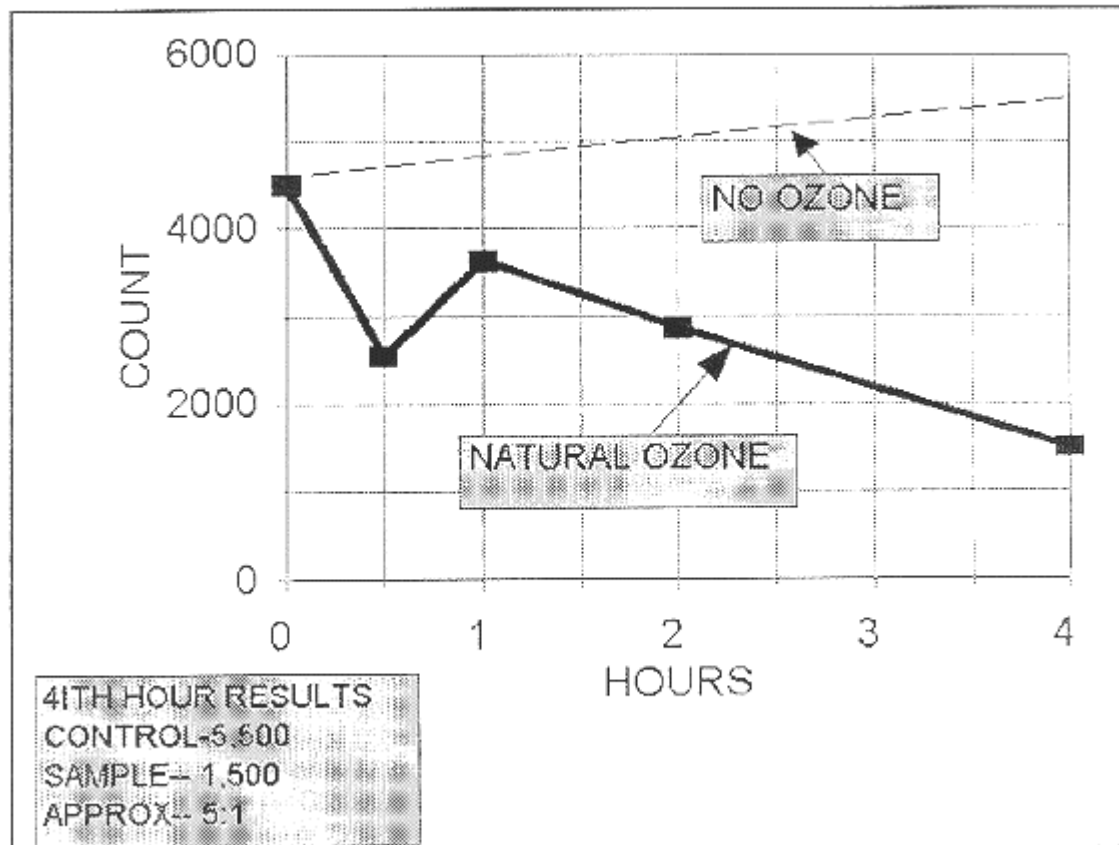
* Secondary Effect: Bleaching

** Secondary Effect: Improved dye-ability

O3 Effects on Fungus @ 0.05 PPM O3

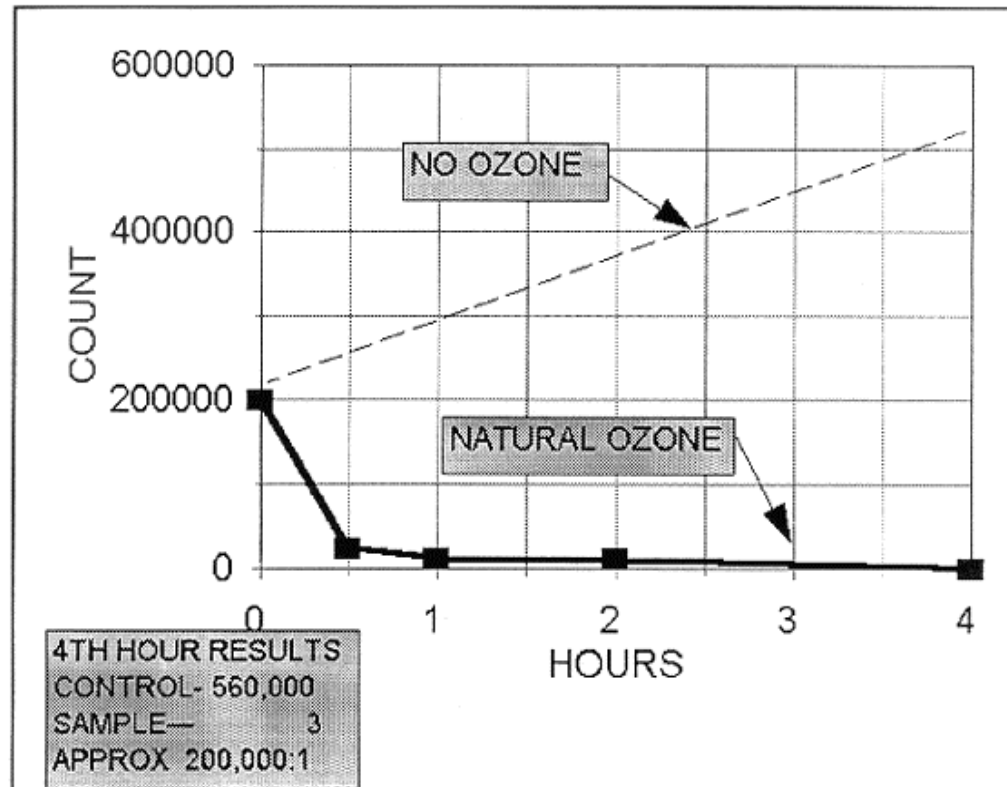
FDA sponsored study

ASPERGILLUS



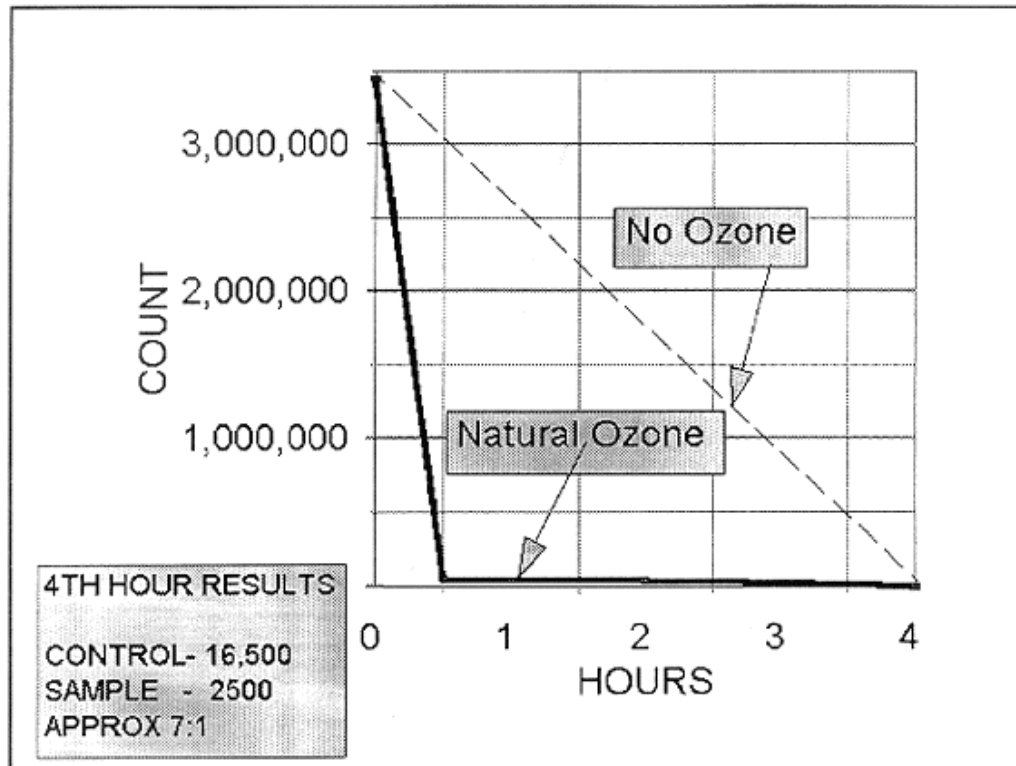
O₃ Effects on Yeasts @ 0.05ppm O₃

CANDIDA



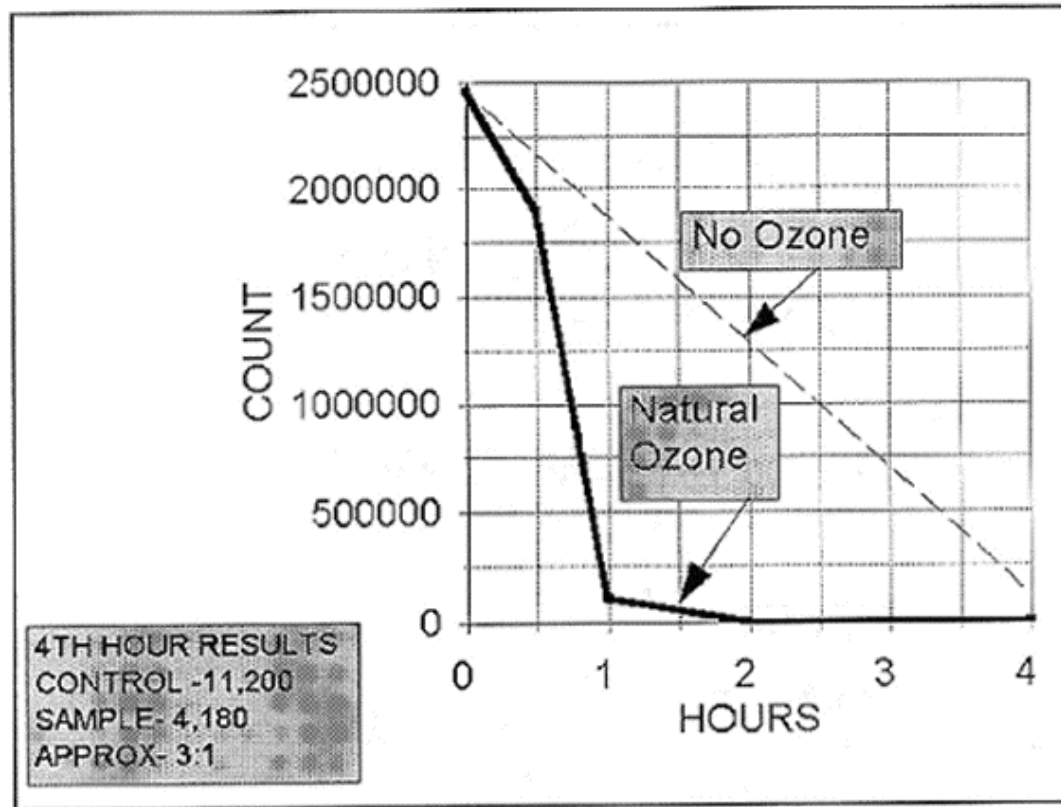
O₃ Effects on Bacteria @ 0.05ppm O₃

E-COLI



O3 Effects on Bacteria@0.05ppm O3

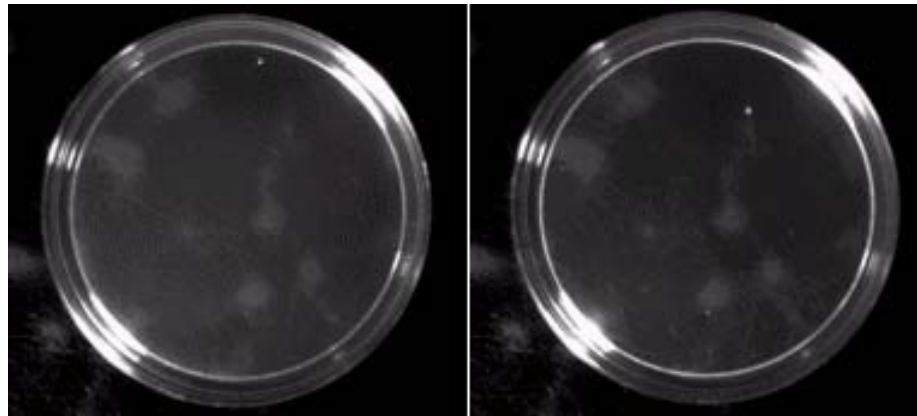
SALMONELLA



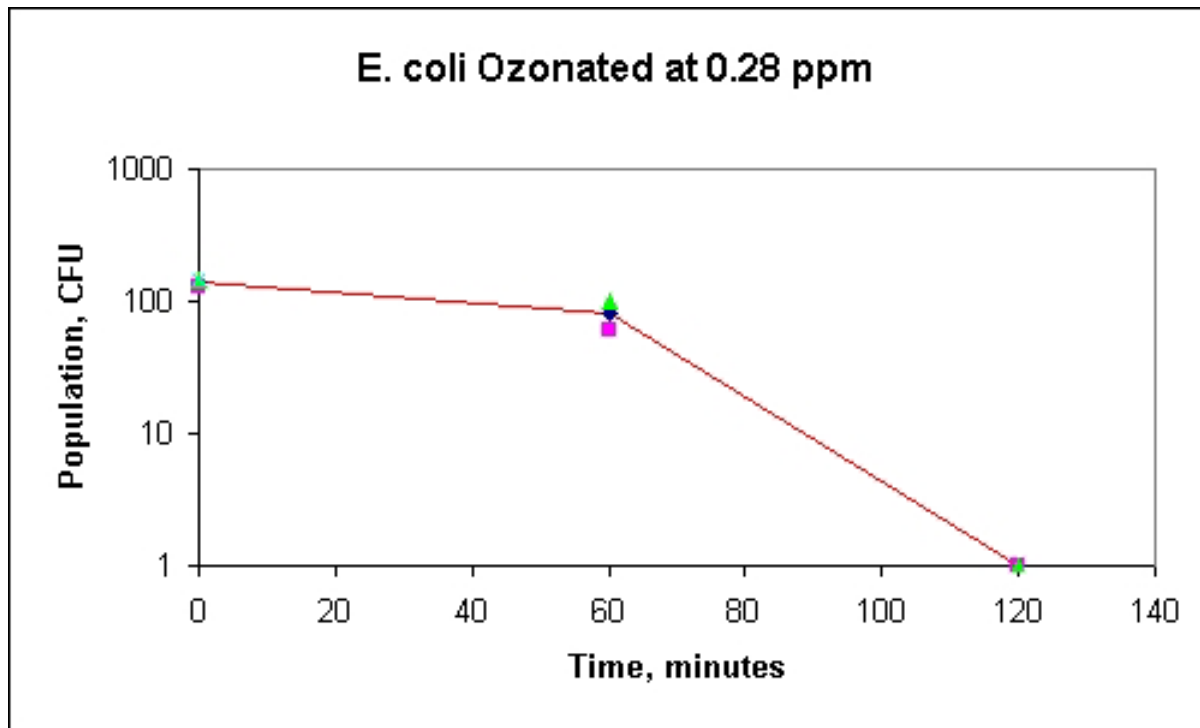
O3 disinfection test



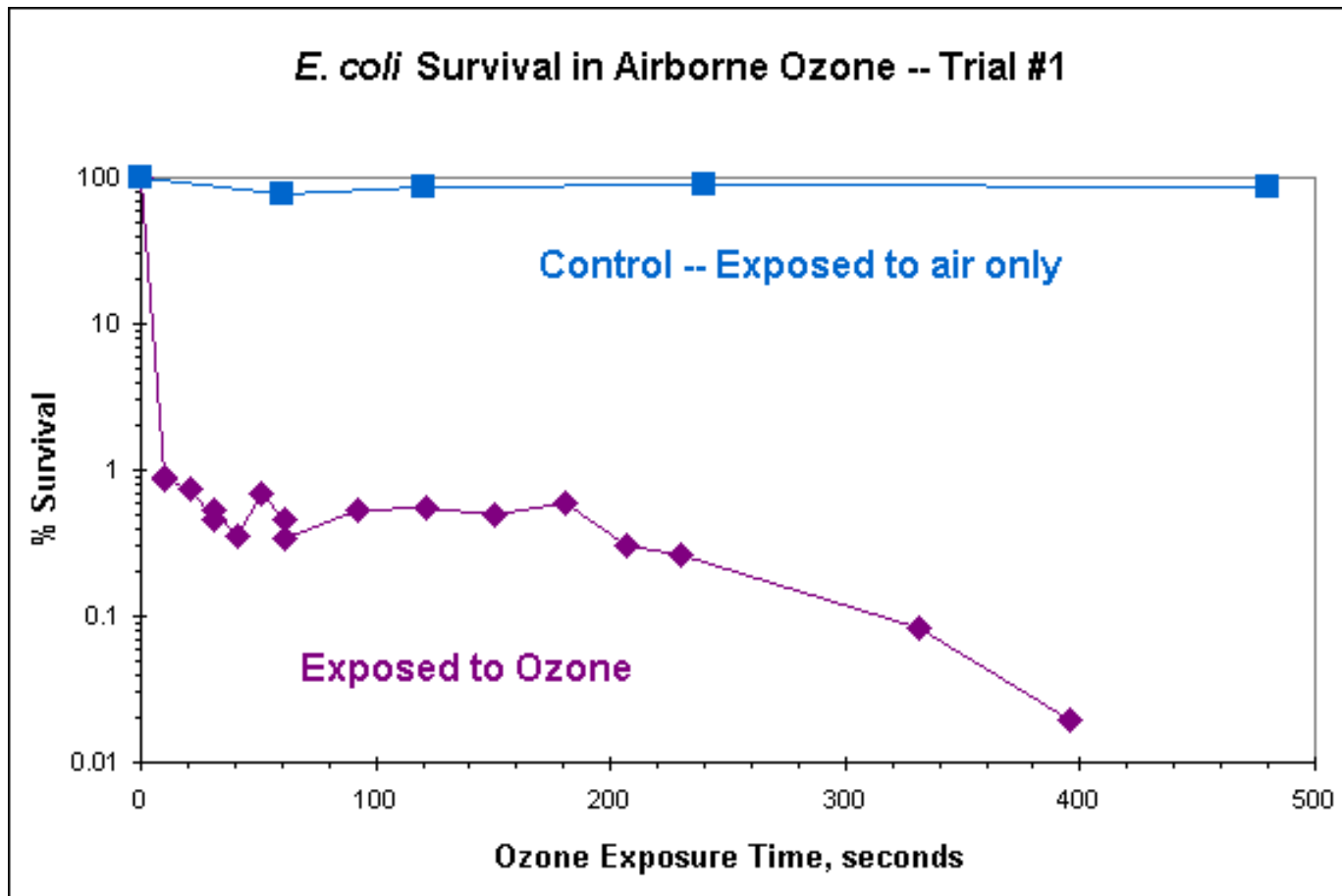
After Exposure to 0.05 PPM O₃



E-Coli Test

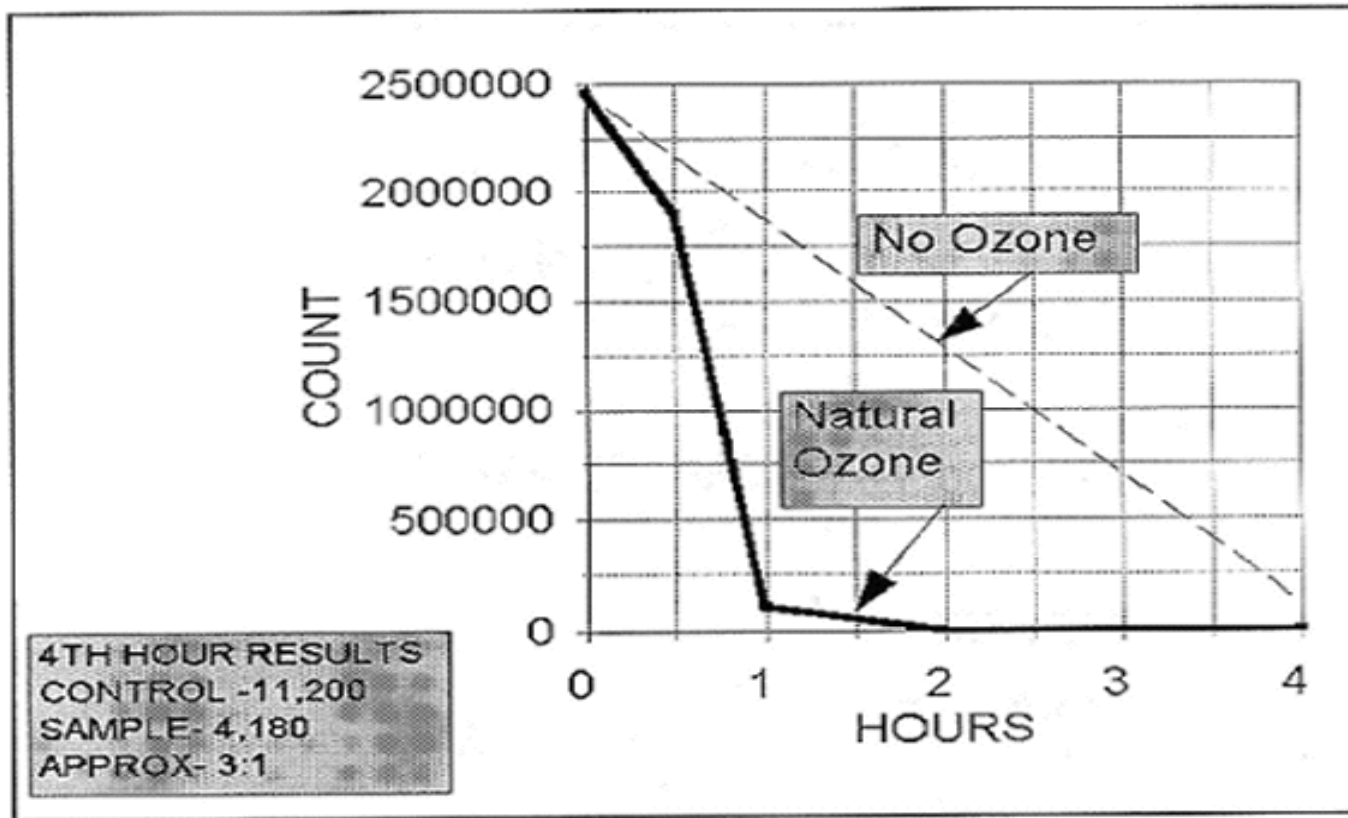


E-Coli Test

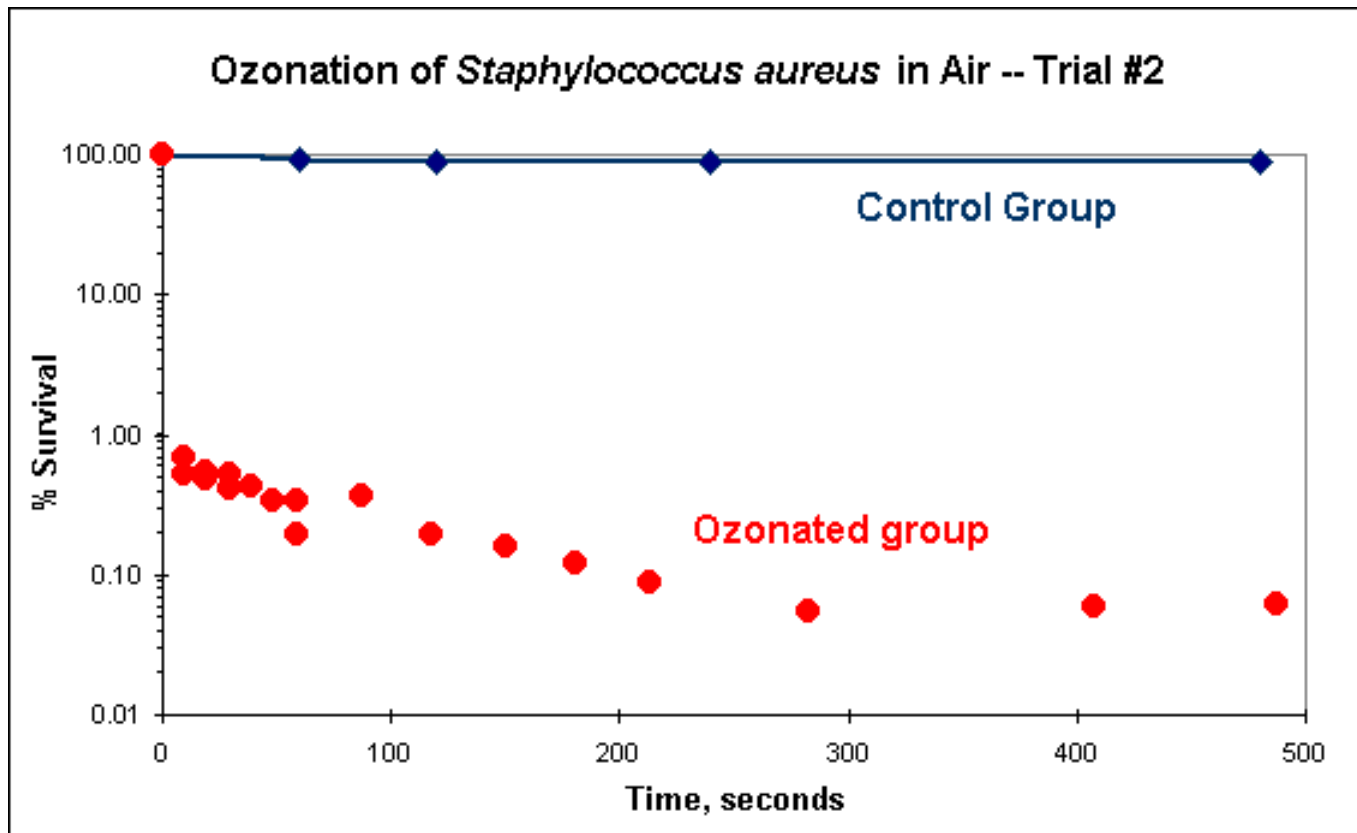


Salmonella destruction

SALMONELLA

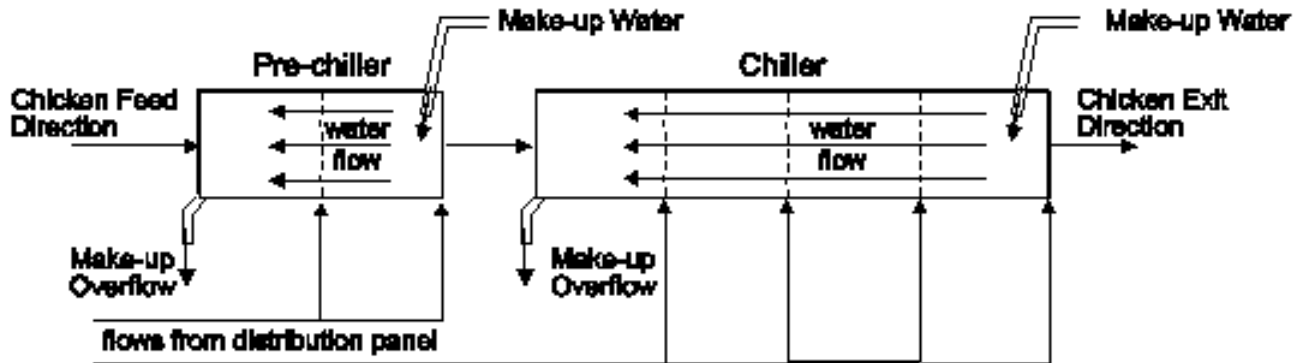


Staphylococcus test



O3 disinfection of Chicken Chillers

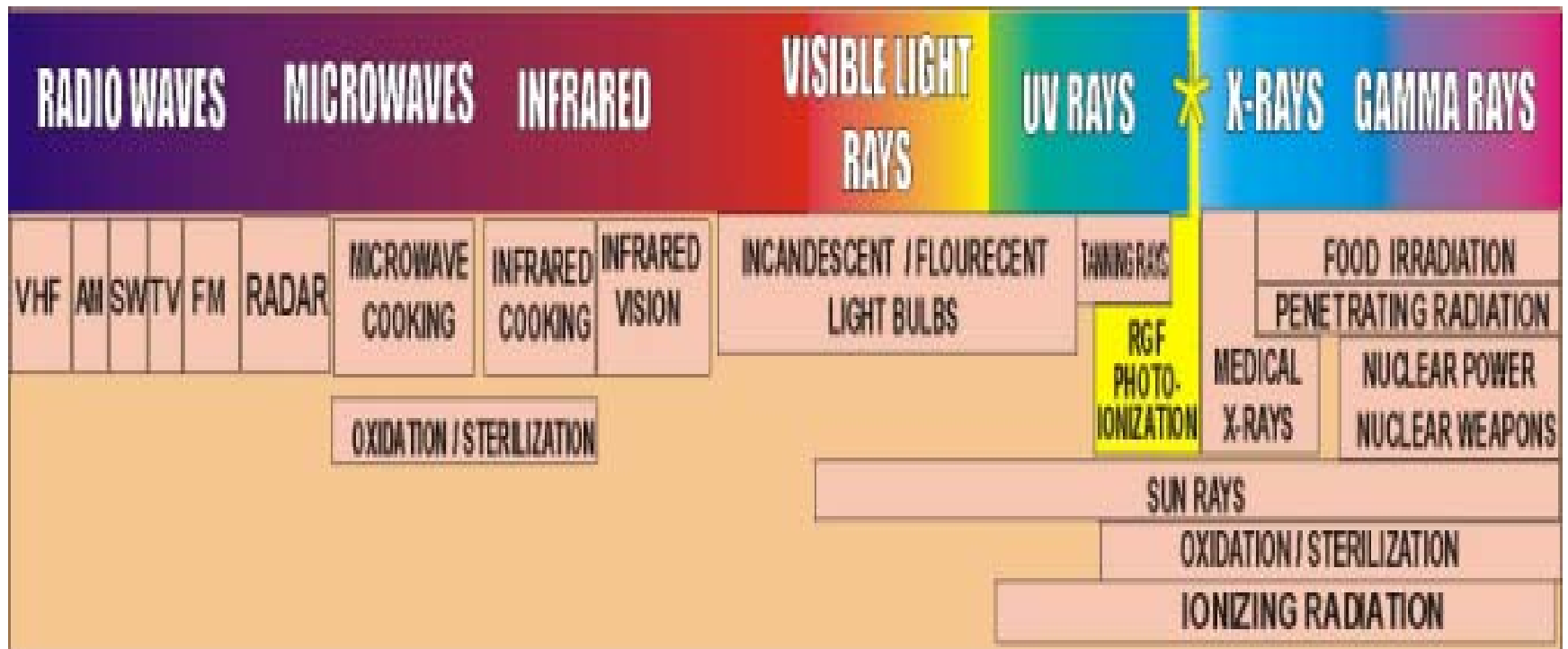
TYPICAL CHILLER LINE
ClO₂ Dosing Points
(overhead view)



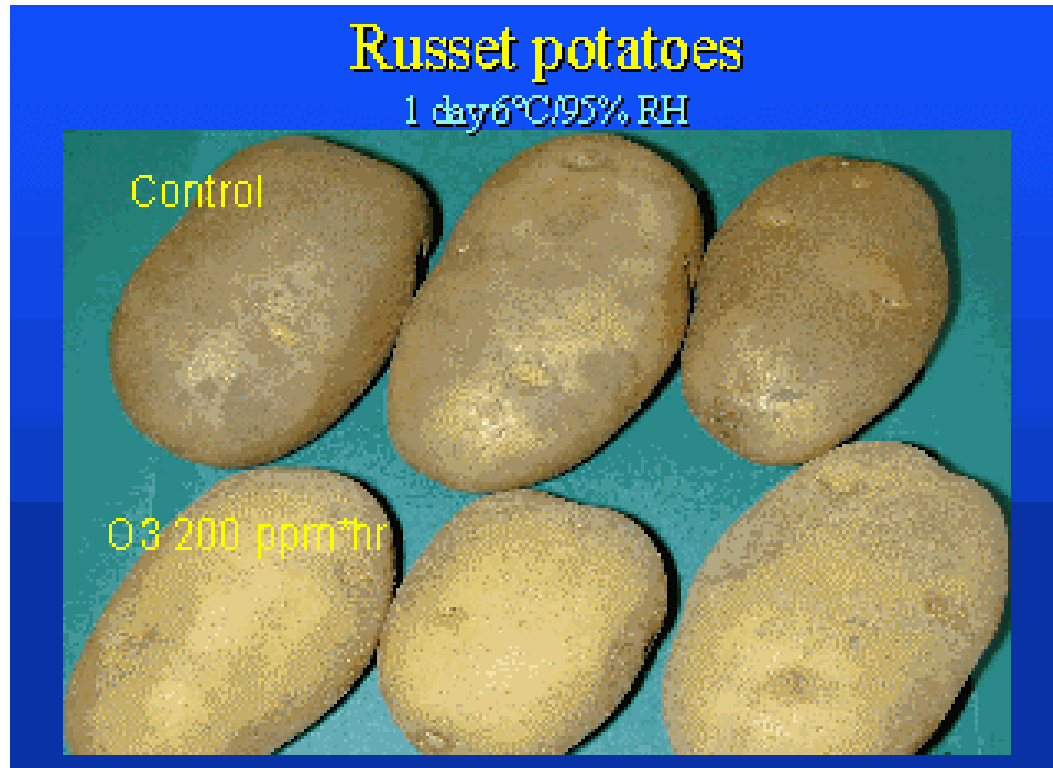
Slaughter House



Radiation Disinfection



Food Preservation



Typical Ozone in water application



Typical Ozone in water application



Typical Ozone in Air application



Conclusion

- FDA, USDA & EPA approved
- Used since the beginning of the century
- Several applications
- Affordable technology

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