Testimonies and comments from health professionals on Ionized Alkaline Water As Well As Numerous Clinical Trials

Dr Raymond Dent" *Alkaline antioxidant water is unlike any water that the average person in our society drinks because it is more than just "water." It's a health drink. Daily use of alkaline antioxidant water may be the best form of natural health maintenance and improvement you can adopt.*

Dr. Ingfreid Hobert, MD "You do not need expensive medicine with all the negative side effects to regain health... Alkaline water has profound long term effects because it alkalizes your body and provides an effective antioxidant."

Dr Hidemitsu Hayashi *Director of the Water Institute, Tokyo,* "Bad diets such as meat and potatoes, fried foods, soft drink colas, and sugars build up acid salts in the body. Often these deposits, by having to be stored away from the blood flow, can remain in the body for decades. He recommends the consumption of ionized alkaline water, which will slowly and gently wash these salts away."

Dr Theodore Baroody *Author, "Alkalize or Die"*"I have administered over 5000 gallons of this water for about every health situation imaginable I feel that restructured alkaline water can benefit everyone"

Felicia Drury Climent *Author, "The Acid Alkaline balance Diet," Adjunct Professor, City College, New York* "After years of very positive continuous clinical experiment that I am conducting with hundreds of clients using electronically restructured alkaline water, it is my opinion that this exciting technology will change the way in which all health providers and the public will approach their health in the coming years.... My suggestion is to drink restructured alkaline water whenever possible."

Dr Sherry Rogers Alkaline water rids the body of acid waste... After carefully evaluating the results of my advice to hundreds of individuals, I'm convinced that toxicity in the form of acidic waste is the primary cause of degenerative disease." "Alkaline water rids the body of acid waste... After carefully evaluating the results of my advice to hundreds of individuals, I'm convinced that toxicity in the form of acidic waste is the primary cause of degenerative disease."

Dr. Susan Lark University lecturer and author of "The Chemistry Of Success" "Drinking four to six glasses of alkaline water a day will help to neutralize over acidity and over time will help to restore your buffering ability.

Dr. Robert O. Young, Ph.D. *In his book, The pH Miracle:* "Those willing to look again, and with clear eyes, will be rewarded with the secrets to permanent health. We can heal ourselves by changing the environment inside our bodies. Potentially harmful invaders, then, will have nowhere to grow and will become harmless."

Arthur C. Guyton, M.D., probably the most recognized author on human physiology states in his " Textbook of Medical Physiology" (used to educate medical students): " The first steps in maintaining health is to alkalize the body (pH or acid/alkaline balance). This is one of the most important aspects of homeostasis. Changes in pH alter virtually all body functions. "

Dr Howard Hay(1930)

"...people with more acidic blood were more likely to be ill. He defined a pH range of 7.4 to 7.5 to be associated with good health. When foods are metabolized, acids are produced which are neutralized by the alkaline salts (carbonates) of calcium, magnesium, potassium and sodium. Foods containing chlorine, phosphorous, sulfur and nitrogen, **animal products and refined carbohydrates tend to be acid forming."**

Ray Kurzweil Talks About Alkaline Water

Dr Kurzweil is one of the world's leading inventors, thinkers, and futurists. He has been awarded 12 honorary doctorates, been honoured by 3 US Presidents and is the recipient of many of the nations highest awards for excellence. Ray drinks 10 glasses of of Alkaline Water per day, and believes it will help him live a long and healthy life. In this short interview he answers a few basic questions about Alkaline Water.

FWSNA

The Functional Water Society of North America (FWSNA) is a recently formed non-profit corporation that promotes the science and technology of functional water. It is associated with the Japanese Functional Water Foundation and participates in their annual Functional Water Symposium. The society maintains an extensive database of technical publications, articles and vendor information pertinent to the production and uses of functional water. This information, along with technical support, is provided to manufactures, users, and researchers of functional water.

Future Applications

There are many applications for functional water. Most of them have been subjected to limited testing and verification. A few of them have been extensively tested and are widely used outside the U.S. (human and animal drinking water, plant growth, food processing, disinfectant, pesticide). Based on this database, here are some possible future uses of functional water (used in the generic sense) in areas of interest to WaterLife.

Use functional water for drinking to enhance the health benefits of nutrients in the water or taken with the water (humans and animals).
Use functional water in cooking to improve the flavor and the nutritional value of foods.
Use functional water for plant growth so that nutrients are more absorbable and less water is required.
Use functional water for disinfection (water, food processing, medical, and mouth wash).
Use functional water for skin problems (dermatitis, bruises, burns, bed sores).
Use functional water to reduce gastrointestinal problems (diarrhea, constipation).

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Alkaline Water and Cancer Research: http://www.adlux.fi/public/pdf/anticancereffect.pdf

"Cancer tumors cannot live in alkaline water. You and I should be drinking alkaline water so our bodies won't provide an environment for cancer tumors to live" by **Mona Harrison, M.D., Chief Medical Officer at the D.C. General Hospital in Washington, DC., former Assistant Dean of the Boston University School of Medicine and former Director of the International Water Council.**

"In my 20 plus years in the health and wellness field, I've never found anything as effective and consistent as Kangen Ionized Water. **Dave Carpenter, N.D., C. Ac., C.C.I.** (Dr. Carpenter has almost 15 years experience using ionizers in his practice and is probably America's preeminent expert in the field of ionizedwater

water is safe, feasible, and easy for the prevention of MRSA infection. Postoperative infection was significantly decreased in the group B as compared in the group A. An electrolyzed strong acid solution may be effective on postoperative infection, particularly MRSA infection following open heart surgery.

PMID: 15553026 [PubMed - indexed for MEDLINE]

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12. Effects of water source, dilution, storage, and bacterial and fecal loads on the efficacy of electrolyzed oxidizing water for the control of Escherichia coli O157:H7.

J Food Prot. 2004 Jul;67(7):1377-83.

Stevenson SM , **Cook SR** , **Bach SJ** , **McAllister TA** .

Agriculture and Agri-Food Canada Research Centre, Lethbridge, Alberta, Canada T1J 4B1.

To evaluate the potential of using electrolyzed oxidizing (EO) water for controlling Escherichia coli O157:H7 in water for livestock, the effects of water source, electrolyte concentration, dilution, storage conditions, and bacterial or fecal load on the oxidative reduction potential (ORP) and bactericidal activity of EO water were investigated. Anode and combined (7:3 anode:cathode, vol/vol) EO waters reduced the pH and increased the ORP of deionized water, whereas cathode EO water increased pH and lowered ORP. Minimum concentrations (vol/vol) of anode and combined EO waters required to kill 10(4) CFU/ml planktonic suspensions of E. coli O157:H7 strain H4420 were 0.5 and 2.0%, respectively. Cathode EO water did not inhibit H4420 at concentrations up to 16% (vol/vol). Higher concentrations of anode or combined EO water were required to elevate the ORP of irrigation or chlorinated tap water compared with that of deionized water. Addition of feces to EO water products (0.5% anode or 2.0% combined, vol/vol) significantly reduced ($P < 0.001$) their ORP values to < 700 mV in all water types. A relationship between ORP and bactericidal activity of EO water was observed. The dilute EO waters retained the capacity to eliminate a 10(4) CFU/ml inoculation of E. coli O157:H7 H4420 for at least 70 h regardless of exposure to UV light or storage temperature (4 versus 24 degrees C). At 95 h and beyond, UV exposure reduced ORP, significantly more so ($P < 0.05$) in open than in closed containers. Bactericidal activity of EO products (anode or combined) was lost in samples in which ORP value had fallen to < or = 848 mV. When stored in the dark, the diluted EO waters retained an ORP of > 848 mV and bactericidal efficacy for at least 125 h; with refrigeration (4 degrees C), these conditions were retained for at least 180 h. Results suggest that EO water may be an effective means by which to control E. coli O157:H7 in livestock water with low organic matter content.

PMID: 15270489 [PubMed - indexed for MEDLINE]

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13. Efficacy of electrolyzed acid water in reprocessing patient-used flexible upper endoscopes: Comparison with 2% alkaline glutaraldehyde.

J Gastroenterol Hepatol. 2004 Aug;19(8):897-903.

Lee JH , **Rhee PL** , **Kim JH** , **Kim JJ** , **Paik SW** , **Rhee JC** , **Song JH** , **Yeom JS** , **Lee NY** .

Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 50 Ilwon-Dong. Kangnam-Ku, Seoul 135-710, Korea.

BACKGROUND AND AIM: Two percent glutaraldehyde, the most widely used liquid chemical germicide (LCG), may be hazardous to patients and medical personnel. Alternatives to glutaraldehyde, such as electrolyzed acid water (EAW), are being developed, but data from well-controlled studies with patient-used endoscopes are rare. The purpose of the present paper was to evaluate the high-level disinfection capability of EAW and compare it with glutaraldehyde. METHODS: A random sample of 125 endoscopes was collected immediately after upper endoscopic examination. After careful manual cleaning, endoscopes were divided into a glutaraldehyde and EAW group. After the disinfection procedure, samples from working channel (S-1), insertion tube (S-2), umbilical cord (S-3), and angulation knob (S-4) were taken and cultured. Another twenty endoscopes were experimentally contaminated with hepatitis B virus (HBV) and samples were collected after contamination (T-1), after manual cleaning (T-2), and after final disinfection (T-3). Polymerase chain reaction (PCR) for HBV-DNA was performed. RESULTS: In the EAW group, culture-positive rates were 3.2% in S-1, 9.5% in S-2, 3.2% in S-3, and 27.0% in the S-4 samples. There was no significant difference between the EAW and glutaraldehyde groups for all sampling sites. However, in both groups, disinfection of the angulation knobs (S-4) was less efficient than the others. For the T-1 site, HBV-DNA was detected from all of them, and in 95% (19/20) of T-2. However, HBV-DNA was not detected from T-3 samples. CONCLUSIONS: Electrolyzed acid water is as efficient as glutaraldehyde in eliminating bacteria from patient-used endoscopes. After disinfection procedures using both methods, HBV-DNA was not detected from any endoscopes experimentally contaminated with HBV-positive mixed sera. However, some bacteria may remain on the surface of the endoscopes. Therefore, more careful precleaning of the endoscopes may help achieve high-level disinfection in the clinical setting.

PMID: 15242493 [PubMed - indexed for MEDLINE]

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14. Efficacy of acidic electrolyzed water for microbial decontamination of cucumbers and strawberries.

J Food Prot. 2004 Jun;67(6):1247-51. **Koseki S** , **Yoshida K** , **Isobe S** , **Itoh K** .

Food Processing Laboratory, National Food Research Institute, 2-1-12 Kannondai, Tsukuba 305-8642, Japan. koseki@nfri.affrc.go.jp

An examination was made of the efficacy of acidic electrolyzed water (AcEW, 30 ppm free available chlorine), ozonated water (5 ppm ozone), and a sodium hypochlorite solution (NaOCl, 150 ppm free available chlorine) for use as potential sanitizers of cucumbers and strawberries. AcEW and NaOCl reduced the aerobic mesophiles naturally present on cucumbers within 10 min by 1.4 and 1.2 log CFU per cucumber, respectively. The reduction by ozonated water (0.7 log CFU per cucumber) was significantly less than that of AcEW or NaOCl ($P < or = 0.05$). Cucumbers washed in alkaline electrolyzed water for 5 min and then treated with AcEW for 5 min showed a reduction in aerobic mesophiles that was at least 2 log CFU per cucumber greater than that of other treatments ($P < or = 0.05$). This treatment was also effective in reducing levels of coliform bacteria and fungi associated with cucumbers. All treatments offered greater microbial reduction on the cucumber surface than in the cucumber homogenate. Aerobic mesophiles associated with strawberries were reduced by less than 1 log CFU per strawberry after each treatment. Coliform bacteria and fungi associated with strawberries were reduced by 1.0 to 1.5 log CFU per strawberry after each treatment. Microbial reduction was approximately 0.5 log CFU per strawberry greater on the strawberry surface than in the strawberry homogenate. However, neither treatment was able to completely inactivate or remove the microorganisms from the surface of the cucumber or strawberry.

PMID: 15222559 [PubMed - indexed for MEDLINE]

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15. The bactericidal effects of electrolyzed oxidizing water on bacterial strains involved in hospital infections.

Artif Organs. 2004 Jun;28(6):590-2. **Vorobjeva NV** , **Vorobjeva LI** , **Khodjaev EY** .

Department of Physiology of Microorganisms, Biology Faculty, Moscow State University, Lenin Hills 1/12, Moscow 119992, Russia. nvvorobjeva@mail.ru

The study is designed to investigate bactericidal actions of electrolyzed oxidizing water on hospital infections. Ten of the most common opportunistic pathogens are used for this study. Cultures are inoculated in 4.5 mL of electrolyzed oxidizing (EO) water or 4.5 mL of sterile deionized water (control), and incubated for 0, 0.5, and 5 min at room temperature. At the exposure time of 30 s the EO water completely inactivates all of the bacterial strains, with the exception of vegetative cells and spores of bacilli which need 5 min to be killed. The results indicate that electrolyzed oxidizing water may be a useful disinfectant for hospital infections, but its clinical application has still to be evaluated.

PMID: 15153153 [PubMed - indexed for MEDLINE]

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16. Bactericidal effects of acidic electrolyzed water on the dental unit waterline.

Jpn J Infect Dis. 2004 Apr;57(2):52-4.

Kohno S , **Kawata T** , **Kaku M** , **Fuita T** , **Tsutsui K** , **Ohtani J** , **Tenjo K** , **Motokawa M** , **Tohma Y** ,**Shigekawa M** , **Kamata H** , **Tanne K** .

Department of Orthodontics and Craniofacial Developmental Biology, Hiroshima University, Hiroshima 734-8553, Japan. acho@hiroshima-u.ac.jp

Many studies have been conducted in the United States regarding the microbial contamination of dental unit waterline, but not in Japan. Recently, acidic electrolyzed water has been used in the medical and dental fields. In this study, we investigated the bactericidal effects of the temporary inflow of acidic electrolyzed water on microbial contamination of the dental unit waterline. First, in order to observe the daily bacterial contamination of the dental unit waterline, water samples were collected at the end of handpieces and three-way syringes before the inflow of acidic electrolyzed water. They were cultured to detect viable bacteria. Later, the inflow of acidic electrolyzed water was conducted through the piping box of the dental unit. Before starting operation on next day, water samples were collected and cultured, as described above. The mean viable bacteria count was 910 -/+ 190 CFU/ml at the end of handpieces, and 521 -/+ 116 CFU/ml at the end of three-way syringes before the inflow of acidic electrolyzed water. However, bacteria were detected in only small numbers at the end of handpieces and three-way syringes on the next day. These results indicated that acidic electrolyzed water could be applied as an appropriate measure against bacterial contamination of the dental unit waterline.

PMID: 15118209 [PubMed - indexed for MEDLINE]

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17. Evaluation of disinfective potential of reactivated free chlorine in pooled tap water by electrolysis.

J Microbiol Methods. 2004 May;57(2):163-73. **Nakajima N** , **Nakano T** , **Harada F** , **Taniguchi H** , **Yokoyama I**, **Hirose J** , **Daikoku E** , **Sano K** .

Department of Microbiology, Osaka Medical College, 2-7 Daigaku-machi Takatsuki, Osaka 569-8686, Japan.

Tap water is one of the causative factors of hospital infections. We examined the disinfective potential of electrolysis and mechanism of disinfection, and clarified the disinfective effect of electrolysis on tap water contaminated with bacteria, and discussed its clinical applications. Tap waters artificially contaminated with Pseudomonas aeruginosa, Escherichia coli, Legionella pneumophila, and Staphylococcus aureus could be sterilized by electrolysis at 20-30 mA for 5 min. A high-density suspension (10(6) CFU/ml) of a spore forming bacterium, Bacillus subtilis was not completely sterilized by electrolysis at 50 mA up to 30 min, but a low-density suspension (10(5) CFU/ml) was totally sterilized by electrolysis at 50 mA for 5 min. Electrolyzed P. aeruginosa changed morphologically, that is, there was bleb formation on the cell wall and irregular aggregation of cytoplasmic small granules. Moreover, cytoplasmic enzyme, nitrate reductase, was inactivated by the electrolysis. On the other hand, genomic DNA of the electrolyzed bacteria was not degenerated, therefore, their DNA polymerase activity was not completely inactivated. Consequently, the major agent in electrolysis for bactericidal action was considered to be free chlorine, and the possible bactericidal mechanism was by destruction of bacterial membranes, followed by the aggregation of peripheral cytoplasmic proteins. Electrolysis of tap water for both disinfecting contaminating bacteria and increasing the disinfectant capacity was considered effective with some limitations, particularly against high-density contamination by spore-forming bacteria. In clinical settings, electrolysis of tap water is considered effective to disinfect water for hand washing in operation theatres, and bathing water for immunocompromised hosts.

PMID: 15063056 [PubMed - indexed for MEDLINE]

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18. Effect of rinsing alginate impressions using acidic electrolyzed water on dimensional change and deformation of stone models.

Dent Mater J. 2003 Dec;22(4):494-506.

Hiraguchi H , **Nakagawa H** , **Uchida H** , **Tanabe N** .

Laboratory of Dental Materials Research, Division of Biomaterials Science, Dental Research Center, Nihon University School of Dentistry 1-8-13 kanda-Surugadai, Chiyoda-ku, Tokyo 101-8310.

This study investigated the effect of rinsing alginate impressions using acidic electrolyzed water on the dimensional change and deformation of stone models. Two brands of alginate impression materials were used. The impressions were rinsed

using tap water or acidic electrolyzed water with a pH of 2.3, an oxidation-reduction potential of 1,230 mV, and a residual chlorine concentration of 45.0 ppm for 30 sec or 3 min. The sectional profiles of the stone models obtained from them were measured using a three-dimensional coordinate measuring system. For the same rinsing time, there was no significant difference in dimensional change between the two types of rinsing water. The change in shape from the master die was approximately the same for the stone models obtained from rinsed impressions using either water. The results suggest that the use of acidic electrolyzed water rather than tap water for rinsing is an acceptable treatment for alginate impressions.

PMID: 15005227 [PubMed - indexed for MEDLINE]

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19. Corrosion behavior of dental alloys in various types of electrolyzed water.

Dent Mater J. 2003 Dec;22(4):482-93.

Dong H , **Nagamatsu Y** , **Chen KK** , **Tajima K** , **Kakigawa H** , **Shi S** , **Kozono Y** .

Pedodontics Research Institute, Tongji University, 2, Lane 158, DaMuQiao Rd., Ste. 402 Shanghai, 200032, PR China.

The corrosion behavior of dental alloys was examined in electrolyzed strong acid water, weak acid water and neutral water using a 7-day immersion test. The precious metal alloys, gold alloy. Au-Ag-Pd alloy and silver alloy showed the greatest surface color change and dissolution of constituents in the strong acid water and the smallest in the neutral water. The release of Au from gold alloy was especially marked in the strong acid water. Co-Cr alloy showed greater corrosion and tarnish resistance in the strong acid water rather than in the weak acid water and the neutral water. X-ray microanalysis revealed that the corrosion products on the precious metal alloys were silver chloride crystals and the thin brown products on Co-Cr alloy were cobalt and chromium oxides. Ti was sound in all three types of electrolyzed water. The neutral water appeared the least corrosive to metals among the three types showing equivalent bactericidal activity.

PMID: 15005226 [PubMed - indexed for MEDLINE]

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20. Effects of chlorine and pH on efficacy of electrolyzed water for inactivating Escherichia coli O157:H7 and Listeria monocytogenes.

Int J Food Microbiol. 2004 Feb 15;91(1):13-8.

Park H , **Hung YC** , **Chung D** .

Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin, GA 30223 1797, USA.

The effects of chlorine and pH on the bactericidal activity of electrolyzed (EO) water were examined against Escherichia coli O157:H7 and Listeria monocytogenes. The residual chlorine concentration of EO water ranged from 0.1 to 5.0 mg/l, and the pH effect was examined at pH 3.0, 5.0, and 7.0. The bactericidal activity of EO water increased with residual

chlorine concentration for both pathogens, and complete inactivation was achieved at residual chlorine levels equal to or higher than 1.0 mg/l. The results showed that both pathogens are very sensitive to chlorine, and residual chlorine level of EO water should be maintained at 1.0 mg/l or higher for practical applications. For each residual chlorine level, bactericidal activity of EO water increased with decreasing pH for both pathogens. However, with sufficient residual chlorine (greater than 2 mg/l), EO water can be applied in a pH range between 2.6 (original pH of EO water) and 7.0 while still achieving complete inactivation of E. coli O157:H7 and L. monocytogenes.

PMID: 14967556 [PubMed - indexed for MEDLINE]

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21. Inactivation of Escherichia coli O157:H7, Salmonella enteritidis and Listeria monocytogenes on the surface of tomatoes by neutral electrolyzed water.

Lett Appl Microbiol. 2003;37(6):482-7.

Deza MA , **Araujo M** , **Garrido MJ** .

Institute of Food Research and Analysis, University of Santiago de Compostela, Santiago de Compostela, Spain. madeza@usc.es

AIMS: To determine the efficacy of neutral electrolyzed water (NEW) in killing Escherichia coli O157:H7, Salmonella enteritidis and Listeria monocytogenes, as well as nonpathogenic E. coli, on the surface of tomatoes, and to evaluate the effect of rinsing with NEW on the organoleptic characteristics of the tomatoes. METHODS AND RESULTS: The bactericidal activity of NEW, containing 444 or 89 mg l(-1) of active chlorine, was evaluated over pure cultures (8.5 log CFU ml(-1)) of the above-mentioned strains. All of them were reduced by more than 6 log CFU ml(-1) within 5 min of exposure to NEW. Fresh tomatoes were surface-inoculated with the same strains, and rinsed in NEW (89 mg l(-1) of active chlorine) or in deionized sterile water (control), for 30 or 60 s. In the NEW treatments, independent of the strain and of the treatment time, an initial surface population of about 5 log CFU sq.cm(-1) was reduced to <1 log CFU sq.cm(-1), and no cells were detected in the washing solution by plating procedure. A sensory evaluation was conducted to ascertain possible alterations in organoleptic qualities, yielding no significant differences with regard to untreated tomatoes. SIGNIFICANCE AND IMPACT OF THE STUDY: Rinsing in NEW reveals as an effective method to control the presence of E. coli O157:H7, S. enteritidis and L. monocytogenes on the surface of fresh tomatoes, without affecting their organoleptic characteristics. This indicates its potential application for the decontamination of fresh produce surfaces.

PMID: 14633103 [PubMed - indexed for MEDLINE]

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22. Reduction of Salmonella enterica on alfalfa seeds with acidic electrolyzed oxidizing water and enhanced uptake of acidic electrolyzed oxidizing water into seeds by gas exchange.

J Food Prot. 2003 Nov;66(11):2017-22. **Stan SD** , **Daeschel MA** .

Department of Food Science and Technology, Oregon State University, 100 Wiegand Hall, Corvallis, Oregon 97331-8575, USA.

Alfalfa sprouts have been implicated in several salmonellosis outbreaks in recent years. The disinfectant effects of acidic electrolyzed oxidizing (EO) water against Salmonella enterica both in an aqueous system and on artificially contaminated alfalfa seeds were determined. The optimum ratio of seeds to EO water was determined in order to maximize the antimicrobial effect of EO water. Seeds were combined with EO water at ratios (wt/vol) of 1:4, 1:10, 1:20, 1:40, and 1:100, and the characteristics of EO water (pH, oxidation reduction potential [ORP], and free chlorine concentration) were determined. When the ratio of seeds to EO water was increased from 1:4 to 1:100, the pH decreased from 3.82 to 2.63, while the ORP increased from +455 to +1,073 mV. EO water (with a pH of 2.54 to 2.38 and an ORP of +1,083 to +1,092 mV) exhibited strong potential for the inactivation of S. enterica in an aqueous system (producing a reduction of at least 6.6 log CFU/ml). Treatment of artificially contaminated alfalfa seeds with EO water at a seed-to-EO water ratio of 1:100 for 15 and 60 min significantly reduced Salmonella populations by 2.04 and 1.96 log CFU/g, respectively ($P < 0.05$), while a Butterfield's buffer wash decreased Salmonella populations by 0.18 and 0.23 log CFU/g, respectively. After treatment, EO water was Salmonella negative by enrichment with or without neutralization. Germination of seeds was not significantly affected ($P > 0.05$) by treatment for up to 60 min in electrolyzed water. The uptake of liquid into the seeds was influenced by the internal gas composition (air, N2, or O2) of seeds before the liquid was added.

PMID: 14627277 [PubMed - indexed for MEDLINE]

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23. Influence of inoculation method, spot inoculation site, and inoculation size on the efficacy of acidic electrolyzed water against pathogens on lettuce.

J Food Prot. 2003 Nov;66(11):2010-6.

Koseki S , **Yoshida K** , **Kamitani Y** , **Itoh K** .

Graduate School of Agriculture, Hokkaido University, Kita 9, Nishi 9, Kita-ku, Sapporo 060-8589, Japan. koseki@nfri.affrc.go.jp

The influence of bacterial inoculation methods on the efficacy of sanitizers against pathogens was examined. Dip and spot inoculation methods were employed in this study to evaluate the effectiveness of acidic electrolyzed water (AcEW) and chlorinated water (200 ppm free available chlorine) against Escherichia coli O157:H7 and Salmonella spp. Ten pieces of lettuce leaf (5 by 5 cm) were inoculated by each method then immersed in 1.5 liters of AcEW, chlorinated water, or sterile distilled water for 1 min with agitation (150 rpm) at room temperature. The outer (abaxial) and inner (adaxial) surfaces of the lettuce leaf were distinguished in the spot inoculation. Initial inoculated pathogen population was in the range 7.3 to 7.8 log CFU/g. Treatment with AcEW and chlorinated water resulted in a 1 log CFU/g or less reduction of E. coli O157:H7 and Salmonella populations inoculated with the dip method. Spot inoculation of the inner surface of the lettuce leaf with AcEW and chlorinated water reduced the number of E. coli O157:H7 and Salmonella by approximately 2.7 and 2.5 log CFU/g, respectively. Spot inoculation of the outer surface of the lettuce leaf with both sanitizers resulted in approximately 4.6 and 4.4 log CFU/g reductions of E. coli O157:H7 and Salmonella, respectively. The influence of inoculation population size was also examined. Each sanitizer could not completely eliminate the pathogens when E. coli O157:H7 and Salmonella cells inoculated on the lettuce were of low population size (10(3) to 10(4) CFU/g), regardless of the inoculation technique.

PMID: 14627276 [PubMed - indexed for MEDLINE]

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24. Effectiveness of electrolyzed acidic water in killing Escherichia coli O157:H7, Salmonella enteritidis, and Listeria monocytogenes on the surfaces of tomatoes.

J Food Prot.

Bari ML , **Sabina Y** , **Isobe S** , **Uemura T** , **Isshiki K** .

Food Hygiene Laboratory, National Food Research Institute Food Technology Division, Kannondai-2-1-12, Tsukuba 305-8642, Japan.

A study was conducted to evaluate the efficacy of electrolyzed acidic water, 200-ppm chlorine water, and sterile distilled water in killing Escherichia coli O157:H7, Salmonella, and Listeria monocytogenes on the surfaces of spot-inoculated tomatoes. Inoculated tomatoes were sprayed with electrolyzed acidic water, 200-ppm chlorine water, and sterile distilled water (control) and rubbed by hand for 40 s. Populations of E. coli O157:H7, Salmonella, and L. monocytogenes in the rinse water and in the peptone wash solution were determined. Treatment with 200-ppm chlorine water and electrolyzed acidic water resulted in 4.87- and 7.85-log10 reductions, respectively, in Escherichia coli O157:H7 counts and 4.69- and 7.46-log10 reductions, respectively, in Salmonella counts. Treatment with 200-ppm chlorine water and electrolyzed acidic water reduced the number of L. monocytogenes by 4.76 and 7.54 log10 CFU per tomato, respectively. This study's findings suggest that electrolyzed acidic water could be useful in controlling pathogenic microorganisms on fresh produce.

PMID: 12696675 [PubMed - indexed for MEDLINE] Comment: J Food Prot. 2003 Sep;66(9):1540; author reply 1540.

"Effectiveness of electrolyzed acidic water in killing Escherichia coli O157:H7, Salmonella enteritidis, and Listeria monocytogenes on the surfaces of tomatoes,"

a comment on: J. Food Prot. 66(4):542-548 (2003).

Wilhelmsen E .

Publication Types:
PMID: 14503702 [PubMed - indexed for MEDLINE]

- Comment
- Letter

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25. Stability of electrolyzed oxidizing water and its efficacy against cell suspensions of Salmonella typhimurium and Listeria monocytogenes.

J Food Prot. 2003 Aug;66(8):1379-84.

Fabrizio KA , **Cutter CN** .

Department of Food Science, 111 Borland Laboratory, The Pennsylvania State University, University Park, Pennsylvania 16802, USA.

Electrolyzed oxidizing (EO) water has proved to be effective against foodborne pathogens attached to cutting boards and poultry surfaces and against spoilage organisms on vegetables; however, its levels of effectiveness against Listeria monocytogenes and Salmonella Typhimurium in cell suspensions have not been compared with those of other treatments. In this study, the oxidation reduction potentials (ORPs), chlorine concentrations, and pHs of acidic and basic EO water were monitored for 3 days at 4 and 25 degrees C after generation. There were no differences between the pHs or ORPs of acidic and basic EO waters stored at 4 or 25 degrees C. However, the free chlorine concentration in acidic EO water stored at 4 degrees C increased after 24 h. In contrast, the free chlorine concentration in acidic EO water stored at 25 degrees C decreased after one day. Cell suspensions of Salmonella Typhimurium and L. monocytogenes were treated with distilled water, chlorinated water (20 ppm), acidified chlorinated water (20 ppm, 4.5 pH), acidic EO water (EOA), basic EO water (EOB), or acidic EO water that was "aged" at 4 degrees C for 24 h (AEOA) for up to 15 min at either 4 or 25 degrees C. The largest reductions observed were those following treatments carried out at 25 degrees C. EOA and AEOA treatments at both temperatures significantly reduced Salmonella Typhimurium populations by > 8 log10 CFU/ml. EOA and AEOA treatments effectively reduced L. monocytogenes populations by > 8 log10 CFU/ml at 25degrees C. These results demonstrate the stability of EO water under different conditions and that EO water effectively reduced Salmonella Typhimurium and L. monocytogenes populations in cell suspensions.

PMID: 12929823 [PubMed - indexed for MEDLINE]

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26. Treatment of Escherichia coli O157:H7 inoculated alfalfa seeds and sprouts with electrolyzed oxidizing water.

Int J Food Microbiol. 2003 Sep 15;86(3):231-7.

Sharma RR , **Demirci A** .

Department of Agricultural and Biological Engineering, Pennsylvania State University, University Park, PA 16802, USA.

Electrolyzed oxidizing water is a relatively new concept that has been utilized in agriculture, livestock management, medical sterilization, and food sanitation. Electrolyzed oxidizing (EO) water generated by passing sodium chloride solution through an EO water generator was used to treat alfalfa seeds and sprouts inoculated with a five-strain cocktail of nalidixic acid resistant Escherichia coli O157:H7. EO water had a pH of 2.6, an oxidation-reduction potential of 1150 mV and about 50 ppm free chlorine. The percentage reduction in bacterial load was determined for reaction times of 2, 4, 8, 16, 32, and 64 min. Mechanical agitation was done while treating the seeds at different time intervals to increase the effectiveness of the treatment. Since E. coli O157:H7 was released due to soaking during treatment, the initial counts on seeds and sprouts were determined by soaking the contaminated seeds/sprouts in 0.1% peptone water for a period equivalent to treatment time. The samples were then pummeled in 0.1% peptone water and spread plated on tryptic soy agar with 5 microg/ml of nalidixic acid (TSAN). Results showed that there were reductions between 38.2% and 97.1% (0.22-1.56 log(10) CFU/g) in the bacterial load of treated seeds. The reductions for sprouts were between 91.1% and 99.8% (1.05-2.72 log(10) CFU/g). An increase in treatment time increased the percentage reduction of E. coli O157:H7. However, germination of the treated seeds reduced from 92% to 49% as amperage to make EO water and soaking time increased. EO water did not cause any visible damage to the sprouts.

PMID: 12915034 [PubMed - indexed for MEDLINE]

27. Effect of electrolyzed oxidizing water and hydrocolloid occlusive dressings on excised burn-wounds in rats.

Chin J Traumatol. 2003 Aug 1;6(4):234-7.

Xin H , **Zheng YJ** , **Hajime N** , **Han ZG** .

Department of Thoracic Surgery, China-Japan Union Hospital, Jilin University, Jilin 130031, China.
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OBJECTIVE: To study the efficacy of electrolyzed oxidizing water (EOW) and hydrocolloid occlusive dressings in the acceleration of epithelialization in excised burn-wounds in rats. METHODS: Each of the anesthetized Sprague-Dawley rats (n=28) was subjected to a third-degree burn that covered approximately 10% of the total body surface area. Rats were assigned into four groups: Group I (no irrigation), Group II (irrigation with physiologic saline), Group III (irrigation with EOW) and Group IV (hydrocolloid occlusive dressing after EOW irrigation). Wounds were observed macroscopically until complete epithelialization was present, then the epithelialized wounds were examined microscopically. RESULTS: Healing of the burn wounds was the fastest in Group IV treated with hydrocolloid occlusive dressing together with EOW. Although extensive regenerative epidermis was seen in each Group, the proliferations of lymphocytes and macrophages associated with dense collagen deposition were more extensive in Group II, III and IV than in Group I. These findings were particularly evident in Group III and IV. CONCLUSIONS: Wound Healing may be accelerated by applying a hydrocolloid occlusive dressing on burn surfaces after they are cleaned with EOW.

PMID: 12857518 [PubMed - indexed for MEDLINE]

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28. Reduced hemodialysis-induced oxidative stress in end-stage renal disease patients by electrolyzed reduced water.

Kidney Int. 2003 Aug;64(2):704-14.

Huang KC , **Yang CC** , **Lee KT** , **Chien CT** .

Department of Family Medicine, National Taiwan University College of Medicine and National Taiwan University Hospital, Taipei, Taiwan.

BACKGROUND: Increased oxidative stress in end-stage renal disease (ESRD) patients may oxidize macromolecules and consequently lead to cardiovascular events during chronic hemodialysis. Electrolyzed reduced water (ERW) with reactive oxygen species (ROS) scavenging ability may have a potential effect on reduction of hemodialysis-induced oxidative stress in ESRD patients. METHODS: We developed a chemiluminescence emission spectrum and high-performance liquid chromatography analysis to assess the effect of ERW replacement on plasma ROS (H2O2 and HOCl) scavenging activity and oxidized lipid or protein production in ESRD patients undergoing hemodialysis. Oxidized markers, dityrosine,

methylguanidine, and phosphatidylcholine hydroperoxide, and inflammatory markers, interleukin 6 (IL-6), and C-reactive protein (CRP) were determined. RESULTS: Although hemodialysis efficiently removes dityrosine and creatinine, hemodialysis increased oxidative stress, including phosphatidylcholine hydroperoxide, and methylguanidine. Hemodialysis reduced the plasma ROS scavenging activity, as shown by the augmented reference H2O2 and HOCl counts (Rh2o2 and Rhocl, respectively) and decreased antioxidative activity (expressed as total antioxidant status in this study). ERW administration diminished hemodialysis-enhanced Rh2o2 and Rhocl, minimized oxidized and inflammatory markers (CRP and IL-6), and partly restored total antioxidant status during 1-month treatment. CONCLUSION: This study demonstrates that hemodialysis with ERW administration may efficiently increase the H2O2- and HOCl-dependent antioxidant defense and reduce H2O2- and HOCl-induced oxidative stress.

PMID: 12846769 [PubMed - indexed for MEDLINE]

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29. Cytotoxic effect of antiseptics: comparison In vitro. In vivo examination of strong acidic electrolyzed water, povidone-iodine, chlorhexidine and benzalkonium chloride

Kansenshogaku Zasshi. 2003 May;77(5):316-22. [Article in Japanese]

Iwasawa A , **Nakamura Y** .

Showa University Fujigaoka Hospital, Department of Clinical Pathology.

Cytotoxic effect and guinea pig wound cure stage, pus fabrication presence in infected wound were compared with strong acidic electrolyzed water (AcEW) and povidone-iodine solution (PVP-I), chlorhexidine (CHG) and benzalkonium chloride (BAC). It gave the following results: In a cytotoxic test, the toxicity was recognized in 0.1%-0.01% PVP-I, in 0.0002-0.0004% CHG, in 10-0.1 micrograms/ml BAC, but there was no toxicity in AcEW. By a guinea pig wound cure process, no significance was recognized between each pharmaceutical agent in epidermal cell migration, but by an inflammation locus area, the significance was considerable in comparison with no-treatment. The pyopoiesis of P. aeruginosa infected wound was recognized in a ratio of 38.2% physiological saline, 27.3% CHG, 20.6% PVP-I and 12.1% AcEW. When pollution locus includes an infection image of bacteria, while draining AcEW instead of physiological saline, disinfection, indication was expected, and, as for the disorder in cure stage. I do not agree with that mentioned above. As for AcEW, availability by organism use was recognized for the cytotoxic effect of antiseptic instead of action of acceleration for wound cure.

PMID: 12806927 [PubMed - indexed for MEDLINE]

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30. Decomposition of ethylene, a flower-senescence hormone, with electrolyzed anode water.

Biosci Biotechnol Biochem. 2003 Apr;67(4):790-6.

Harada K , **Yasui K** .

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Electrolyzed anode water (EAW) markedly extended the vase life of cut carnation flowers. Therefore, a flower-senescence hormone involving ethylene decomposition by EAW with potassium chloride as an electrolyte was investigated. Ethylene was added externally to EAW, and the reaction between ethylen and the available chlorine in EAW was examined. EAW had a low pH value (2.5), a high concentration of dissolved oxygen, and extremely high redox potential (19.2 mg/l and 1323 mV, respectively) when available chlorine was at a concentration of about 620 microns. The addition of ethylene to EAW led to ethylene decomposition, and an equimolar amount of ethylene chlorohydrine with available chlorine was produced. The ethylene chlorohydrine production was greatly affected by the pH value (pH 2.5, 5.0 and 10.0 were tested), and was faster in an acidic solution. Ethylene chlorohydrine was not produced after ethylene had been added to EAW at pH 2.6 when available chlorine was absent, but was produced after potassium hypochlorite had been added to such EAW. The effect of the pH value of EAW on the vase life of cut carnations was compatible with the decomposition rate of ethylene in EAW of the same pH value. These results suggest that the effect of EAW on the vase life of cut carnations was due to the decomposition of ethylene to ethylene chlorohydrine by chlorine from chlorine compounds.

PMID: 12784619 [PubMed - indexed for MEDLINE]

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31. Effect of rinsing hydrocolloid impressions using acidic electrolyzed water on surface roughness and surface hardness of stone models.

J Oral Sci. 2002 Dec;44(3-4):141-6 **Nakagawa H** , **Hiraguchi H** , **Uchida H** , **Tanabe N** .

Laboratory of Dental Materials Research, Division of Biomaterials Science, Dental Research Center, Nihon University School of Dentistry, Tokyo 101-8310, Japan. nakagawa@dent.nihon-u.ac.jp

The present study investigated the effect on the surface quality of resultant stone models of rinsing hydrocolloid impressions using acidic electrolyzed water. Two brands of alginate impression materials (Aroma Fine DFIII, Jeltrate Plus), an agar impression material (Ajisai) designed for agar/alginate combined impression, and dental stone (New Plastone) were used to make the test specimens. For the rinsing of impressions, acidic electrolyzed water having a pH value of 2.3, an oxidation-reduction potential of 1,230 mV, and a residual chlorine concentration of 45.0 ppm, was prepared. Alginate, agar and agar/alginate combined impressions were rinsed using acidic electrolyzed water or tap water for 30 sec and 3 min, and as a control, these impressions were not rinsed with any water. Disk-shaped stone specimens obtained from rinsed impressions were evaluated with respect to surface roughness (Ra) and surface hardness (scratch depth), and scanning electron microscope (SEM) observations were performed. The stone specimens obtained from rinsed impressions using acidic electrolyzed water showed a surface quality equivalent to that of the stone specimens obtained from the rinsed impression using tap water. This result suggests that the use of acidic electrolyzed water for rinsing is an acceptable treatment for hydrocolloid impressions, so long as the rinsing time is from 30 sec to 3 min.

PMID: 12613503 [PubMed - indexed for MEDLINE]

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32. Efficacy of electrolyzed oxidizing water in inactivating Salmonella on alfalfa seeds and sprouts.

J Food Prot. 2003 Feb;66(2):208-14.

Kim C , **Hung YC** , **Brackett RE** , **Lin CS** .

Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin, Georgia 30223-1797, USA.

Studies have demonstrated that electrolyzed oxidizing (EO) water is effective in reducing foodborne pathogens on fresh produce. This study was undertaken to determine the efficacy of EO water and two different forms of chlorinated water (chlorine water from Cl2 and Ca(OCl)2 as sources of chlorine) in inactivating Salmonella on alfalfa seeds and sprouts. Tengram sets of alfalfa seeds inoculated with a five-strain cocktail of Salmonella (6.3 x 10(4) CFU/g) were subjected to 90 ml of deionized water (control), EO water (84 mg/liter of active chlorine), chlorine water (84 mg/liter of active chlorine), and Ca(OCl)2 solutions at 90 and 20,000 mg/liter of active chlorine for 10 min at 24 +/- 2 degrees C. The application of EO water, chlorinated water, and 90 mg/liter of Ca(OCl)2 to alfalfa seeds for 10 min reduced initial populations of Salmonella by at least 1.5 log10 CFU/g. For seed sprouting, alfalfa seeds were soaked in the different treatment solutions described above for 3 h. Ca(OCl)2 (20,000 mg/liter of active chlorine) was the most effective treatment in reducing the populations of Salmonella and non-Salmonella microflora (4.6 and 7.0 log10 CFU/g, respectively). However, the use of high concentrations of chlorine generates worker safety concerns. Also, the Ca(OCl)2 treatment significantly reduced seed germination rates (70% versus 90 to 96%). For alfalfa sprouts, higher bacterial populations were recovered from treated sprouts containing seed coats than from sprouts with seed coats removed. The effectiveness of EO water improved when soaking treatments were applied to sprouts in conjunction with sonication and seed coat removal. The combined treatment achieved 2.3- and 1.5-log10 CFU/g greater reductions than EO water alone in populations of Salmonella and non-Salmonella microflora, respectively. This combination treatment resulted in a 3.3-log10 CFU/g greater reduction in Salmonella populations than the control (deionized water) treatment.

PMID: 12597478 [PubMed - indexed for MEDLINE]

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33. The effect of electrolyzed oxidative water applied using electrostatic spraying on pathogenic and indicator bacteria on the surface of eggs.

Poult Sci. 2003 Jan;82(1):158-62.

Russell SM .

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Research was conducted to compare the effectiveness of electrolyzed oxidative (EO) water applied using an electrostatic spraying system (ESS) for killing populations of bacteria that are of concern to the poultry industry. Populations of pathogenic bacteria (Salmonella typhimurium, Staphylococcus aureus, and Listeria monocytogenes), and the indicator bacterium Escherichia coli were applied to eggs and allowed to attach for 1 h. EO water completely eliminated all Salmonella typhimurium on 3, 7, 1, and 8 out of 15 eggs in Repetitions (Rep) 1, 2, 3, and 4, respectively, even when very high inoculations were used. EO water completely eliminated all Staphylococcus aureus on 12, 11, 12, and 11 out of 15 eggs

in Rep 1, 2, 3, and 4, respectively. EO water completely eliminated all Listeria monocytogenes on 8, 13, 12, and 14 out of 15 eggs in Reps 1, 2, 3, and 4, respectively. EO water completely eliminated all Escherichia coli on 9, 11, 15, and 11 out of 15 eggs in Reps 1, 2, 3, and 4, respectively. Even when very high concentrations of bacteria were inoculated onto eggs (many times higher than would be encountered in industrial situations), EO water was found to be effective when used in conjunction with electrostatic spraying for eliminating pathogenic and indicator populations of bacteria from hatching eggs.

PMID: 12580260 [PubMed - indexed for MEDLINE]

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34. Electrochemical removal of bromide and reduction of THM formation potential in drinking water.

Water Res. 2002 Nov;36(19):4902-6.

Kimbrough DE , **Suffet IH** .

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Trihalomethanes (THMs), a by-product of the chlorination of natural waters containing dissolved organic carbon and bromide, are the focus of considerable public health concern and regulation due to their potential as a carcinogen by ingestion. This paper presents a promising new water treatment process that lowers the concentration of bromide in drinking water and thus, lowers the THM formation potential. Bromide is oxidized by electrolysis to bromine and then the bromine apparently volatilized. The electrolyzed water, when chlorinated, produces measurably lower amounts of THMs and proportionately fewer brominated THMs, which are of greater public health concern than the chlorinated THMs. Removing bromide should also reduce the formation of other disinfection by-products such as bromate and haloacetic acids.

PMID: 12448534 [PubMed - indexed for MEDLINE]

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35. Comparison of electrolyzed oxidizing water with various antimicrobial interventions to reduce Salmonella species on poultry.

Poult Sci. 2002 Oct;81(10):1598-605.

Fabrizio KA , **Sharma RR** , **Demirci A** , **Cutter CN** .

Department of Food Science, The Pennsylvania State University, University Park 16802, USA.

Foodborne pathogens in cell suspensions or attached to surfaces can be reduced by electrolyzed oxidizing (EO) water;

however, the use of EO water against pathogens associated with poultry has not been explored. In this study, acidic EO water [EO-A; pH 2.6, chlorine (CL) 20 to 50 ppm, and oxidation-reduction potential (ORP) of 1,150 mV], basic EO water (EO-B; pH 11.6, ORP of -795 mV), CL, ozonated water (OZ), acetic acid (AA), or trisodium phosphate (TSP) was applied to broiler carcasses inoculated with Salmonella Typhimurium (ST) and submerged (4 C, 45 min), spray-washed (85 psi, 25 C, 15 s), or subjected to multiple interventions (EO-B spray, immersed in EO-A; AA or TSP spray, immersed in CL). Remaining bacterial populations were determined and compared at Day 0 and 7 of aerobic, refrigerated storage. At Day 0, submersion in TSP and AA reduced ST 1.41 log10, whereas EO-A water reduced ST approximately 0.86 log10. After 7 d of storage, EO-A water, OZ, TSP, and AA reduced ST, with detection only after selective enrichment. Spray-washing treatments with any of the compounds did not reduce ST at Day 0. After 7 d of storage, TSP, AA, and EO-A water reduced ST 2.17, 2.31, and 1.06 log10, respectively. ST was reduced 2.11 log10 immediately following the multiple interventions, 3.81 log10 after 7 d of storage. Although effective against ST, TSP and AA are costly and adversely affect the environment. This study demonstrates that EO water can reduce ST on poultry surfaces following extended refrigerated storage.

PMID: 12412930 [PubMed - indexed for MEDLINE]

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36. Behavior of hydrogen peroxide in electrolyzed anode water.

Biosci Biotechnol Biochem. 2002 Sep;66(9):1783-91.

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Oxygen electrodes and spectrophotometric analysis have been used to evaluate the contribution of H2O2, in addition to available chlorine, to the high redox potential of electrolyzed anode water (EAW) with potassium chloride as an electrolyte. H2O2 was added externally to EAW, and the reaction between H2O2 and the available chlorine in the water was examined. EAW has a low pH (2.5), a high concentration of dissolved oxygen, and extremely high redox potentials (19 mg/l and 1,319 mV) when the available chlorine is at the concentration of about 580 microM. The addition of H2O2 to EAW led to H2O2 decomposition, and the amount of oxygen produced was equivalent to the amount of available chlorine. Oxygen production was reduced by ascorbic acid, and completely inhibited by 600 microM ascorbate. The rate of oxygen production was much affected by pH, and was slowest at or near pH 5.0. Rates were particularly high in alkaline solution. Absorbance at 235 nm (pH 3.0 and 5.0) and 292 nm (pH 10.0) decreased when H2O2 was added to the EAW at these pHs, and the extent of decrease was similar pH dependency to that of the oxygen production rate. Oxygen was not produced after H2O2 was added to EAW at pH 2.6 when available chlorine was absent, but oxygen was produced after potassium hypochlorite was added to such EAW. The oxygen production rates in EAW without available chlorine at pH 5.0 and 2.0, pH adjustment with KOH and HCl, respectively, were faster than the rate at pH 2.6, and fastest at pH 2.0. These results suggest that H2O2 or hydroxyl radicals derived from Fenton's reaction did not contribute to the high redox potential of EAW prepared with chlorine compounds as an electrolyte, so that the decomposition of H2O2 occurred rapidly with the reactions of chlorine and hypochlorite ions in EAW.

PMID: 12400674 [PubMed - indexed for MEDLINE]

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37. Durability of bactericidal activity in electrolyzed neutral water by storage.

Dent Mater J. 2002 Jun;21(2):93-104.

Nagamatsu Y , **Chen KK** , **Tajima K** , **Kakigawa H** , **Kozono Y** .

Department of Materials Science, Kyushu Dental College, Kokurakita, Kitakyushu, Japan.

Electrolyzed strong and weak acid waters have been widely used for sterilization in clinical dentistry because of their excellent bactericidal activities. Electrolyzed neutral water was recently developed with a new concept of long-term good durability in addition to the excellent bactericidal activity similar to acid waters. The present study, evaluated the storage life of this water compared with the acid waters in terms of the changes in pH, oxidation-reduction potential (ORP), residual chlorine and bactericidal activity under several conditions using Staphylococcus aureus 209P. The strong acid water showed a rapid deterioration of its bactericidal activity. The weak acid and neutral waters exhibited excellent durability. Although all the bacteria were annihilated by the contact with the waters even stored for 40 days in the uncapped bottle, the neutral water was superior in further long-term duration.

PMID: 12238791 [PubMed - indexed for MEDLINE]

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38. Effectiveness of electrolyzed water as a sanitizer for treating different surfaces.

J Food Prot. 2002 Aug;65(8):1276-80.

Park H , **Hung YC** , **Kim C** .

Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.

The effectiveness of electrolyzed (EO) water at killing Enterobacter aerogenes and Staphylococcus aureus in pure culture was evaluated. One milliliter (approximately 10(9) CFU/ml) of each bacterium was subjected to 9 ml of EO water or control water (EO water containing 10% neutralizing buffer) at room temperature for 30 s. Inactivation (reduction of > 9 log10 CFU/ ml) of both pathogens occurred within 30 s after exposure to EO water containing approximately 25 or 50 mg of residual chlorine per liter. The effectiveness of EO water in reducing E. aerogenes and S. aureus on different surfaces (glass, stainless steel, glazed ceramic tile, unglazed ceramic tile, and vitreous china) was also evaluated. After immersion of the tested surfaces in EO water for 5 min without agitation, populations of E. aerogenes and S. aureus were reduced by 2.2 to 2.4 log10 CFU/ cm2 and by 1.7 to 1.9 log10 CFU/cm2, respectively, whereas washing with control water resulted in a reduction of only 0.1 to 0.3 log10 CFU/cm2. The washing of tested surfaces in EO water with agitation (50 rpm) reduced populations of viable cells on the tested surfaces to < 1 CFU/cm2. For the control water treatment with agitation, the surviving numbers of both strains on the tested surfaces were approximately 3 log10 CFU/cm2. No viable cells of either strain were observed in the EO water after treatment, regardless of agitation. However, large populations of both pathogens were recovered from control wash solution after treatment.

PMID: 12182480 [PubMed - indexed for MEDLINE]

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39. Antimicrobial effects and efficacy on habitually hand-washing of strong acidic electrolyzed water--a comparative study of alcoholic antiseptics and soap and tap water

Kansenshogaku Zasshi. 2002 May;76(5):373-7. [Article in Japanese]

Sakashita M , **Iwasawa A** , **Nakamura Y** .

Department of Nursing, Showa University Fujigaoka Hospital.

The rate of bacterial elimination for the stamp method was compared with regular hand-washing (using soap and tap water), hygienic hand-washing (using alcoholic antiseptics), and hand-washing using strong acidic electrolyzed water (the SAEW method) in routine work. After routine work, the average number of bacteria remaining on the nurse's hands with using the SAEW-method, rubbing method and tap water method, were: 54 +/- 63, 89 +/- 190, 128 +/- 194 CFU/agar plate, respectively (n = 81). In this study. It was clarified that a much larger number of Bacillus sp. were detected for the rubbing method than for the other methods. After further nurse work, the most number of absorbed bacteria on a nurse's hands were counted after cleaning a patient's body. The rate of bacteria elimination for hand-washing with soap and tap water after taking care of a patient was insufficient, especially when before care was provided the number of bacteria on the nurse's hands were less than 100 CFU/agar plate. From these results, the following manual for sanitary hand washing is recommended: 1. At first, dirty hands should be cleaned and the number of bacteria should be reduced using soap and tap water or by scrubbing with disinfectants. 2. After the number of bacteria has been reduced, use the SAEW method routinely. 3. For care requiring a high level of cleanliness or if no tap water facilities are available, use the rubbing method. Finally, routine use of the SAEW method in ICU could be recommended with conventional disinfectants and soap and tap water on a case by case basis for less than adverse reactions, such as in the case of rough-hands or keeping a low level of bacteria on hands.

PMID: 12073573 [PubMed - indexed for MEDLINE]

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40. Bactericidal activity of electrolyzed acid water from solution containing sodium chloride at low concentration, in comparison with that at high concentration.

J Microbiol Methods. 2002 May;49(3):285-93.

Kiura H , **Sano K** , **Morimatsu S** , **Nakano T** , **Morita C** , **Yamaguchi M** , **Maeda T** , **Katsuoka Y** .

Department of Microbiology, Osaka Medical College, Takatsuki, Osaka 569-8686, Japan.

Electrolyzed strong acid water (ESW) containing free chlorine at various concentrations is becoming to be available in clinical settings as a disinfectant. ESW is prepared by electrolysis of a NaCl solution, and has a corrosive activity against medical instruments. Although lower concentrations of NaCl and free chlorine are desired to eliminate corrosion, the germicidal effect of ESW with low NaCl and free-chlorine concentrations (ESW-L) has not been fully clarified. In this study, we demonstrated that ESW-L possesses bactericidal activity against Mycobacteria and spores of Bacillus subtilis. The effect was slightly weaker than that of ESW containing higher NaCl and free-chlorine concentrations (ESW-H), but acceptable as a disinfectant. To clarify the mechanism of the bactericidal activity, we investigated ESW-L-treated Pseudomonas aeruginosa by transmission electron microscopy, a bacterial enzyme assay and restriction fragment length polymorphism pattern (RFLP) assay. Since the bacterium, whose growth was completely inhibited by ESW-L, revealed the inactivation of cytoplasmic enzyme, blebs and breaks in its outer membrane and remained complete RFLP of DNA, damage of the outer membrane and inactivation of cytoplasmic enzyme are the important determinants of the bactericidal activity.

PMID: 11869793 [PubMed - indexed for MEDLINE]

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41. Observation on the effect of disinfection to HBsAg by electrolyzed oxidizing water

Zhonghua Liu Xing Bing Xue Za Zhi. 2001 Feb;22(1):40-2. [Article in Chinese]

Gao Z , **Yin W** , **Han C** , **Zhang J** , **Jin W** , **Li X** .

Nosocomial Infection Department China-Japan Friendship Hospital, Beijing 100029, China.

OBJECTIVE: Observation on the effect of disinfection on gastroscope, contaminated by hepatitis B surface antigen (HBsAg) in the electrolyzed oxidizing water (EOW). METHODS: Contaminated gastric juice and serum was added to EOW for 1 minute. Positive control samples were treated with PBS instead of EOW in the same way. Gastroscopes used for hepatitis patients were immersed in the EOW for 1 minute after cleaning. Samples were collected before and after treatment. ELISA was used to test HBsAg. RESULTS: With mixed samples (average S/N = 42.16) of EOW, HBsAg became negative when diluted in 100 times. However, the HBsAg of positive control samples remained positive. After cleaning the gastroscope (average S/N = 5.99) immersed in EOW, HBsAg became negative. CONCLUSION: EOW was effective in destroying HBsAg which could be used for gastroscope disinfection.

PMID: 11860842 [PubMed - in process]

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42. Decontaminative effect of frozen acidic electrolyzed water on lettuce.

J Food Prot. 2002 Feb;65(2):411-4. **Koseki S** , **Fujiwara K** , **Itoh K** .

Graduate School of Agriculture, Hokkaido University, Sapporo, Japan. koseki@bpe.agr.hokudai.ac.jp

We investigated the effects of frozen acidic electrolyzed water (AcEW) on lettuce during storage in a styrene-foam container. The lettuce was kept at 2 to 3 degrees C for 24 h. Populations of aerobic bacteria associated with lettuce packed in frozen AcEW were reduced by 1.5 log CFU/g after storage for 24 h. With frozen tap water, no microorganism populations tested in this study were reduced. A frozen mixture of AcEW and alkaline electrolyzed water (AlEW) also failed to reduce populations of microorganisms associated with lettuce. Although chlorine gas was produced by frozen AcEW, it was not produced by the AcEW-AlEW mixture. This result indicates that the main factor in the decontaminative effect of frozen AcEW was the production of chlorine gas. Accordingly, low-temperature storage and decontamination could be achieved simultaneously with frozen AcEW during distribution.

PMID: 11848576 [PubMed - indexed for MEDLINE]

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43. Effect of nitrogen gas packaging on the quality and microbial growth of fresh-cut vegetables under low temperatures.

J Food Prot. 2002 Feb;65(2):326-32. **Koseki S** , **Itoh K** .

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Nitrogen (N2) gas packaging for fresh-cut vegetables (lettuce and cabbage) has been examined as a means of modified atmosphere packaging (MAP) for extending the shelf life of cut vegetables. Gas composition in enclosed packages that contained cut vegetables and were filled with 100% N2 had an oxygen (O2) concentration of 1.2 to 5.0% and a carbon dioxide (CO2) concentration of 0.5 to 3.5% after 5 days of storage. An atmosphere of low concentrations of O2 and high CO2 conditions occurred naturally in the package filled with N2 gas. Degradation of cut vegetables in terms of appearance was delayed by N2 gas packaging. Because of this effect, the appearance of fresh-cut vegetables packaged with N2 gas remained acceptable at temperatures below 5 degrees C after 5 days. Treatment with acidic electrolyzed water (AcEW) contributed to the acceptability of the vegetables' appearance at 5 and 10 degrees C in the air-packaging system. N2 gas packaging did not significantly affect the growth of microbial populations (total aerobic bacteria, coliform bacteria, Bacillus cereus, and psychrotrophic bacteria) in or on cut vegetables at 1, 5, and 10 degrees C for 5 days. Microbial growth in or on the cut vegetables was inhibited at 1 degrees C for 5 days regardless of atmospheric conditions.

PMID: 11848563 [PubMed - indexed for MEDLINE]

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44. Antimicrobial effect of electrolyzed water for inactivating Campylobacter jejuni during poultry washing.

Int J Food Microbiol. 2002 Jan 30;72(1-2):77-83. **Park H** , **Hung YC** , **Brackett RE** .

Department of Food Science and Technology College of Agricultural and Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.

The effectiveness of electrolyzed (EO) water for killing Campylobacter jejuni on poultry was evaluated. Complete inactivation of C. jejuni in pure culture occurred within 10 s after exposure to EO or chlorinated water, both of which contained 50 mg/l of residual chlorine. A strong bactericidal activity was also observed on the diluted EO water (containing 25 mg/l of residual chlorine) and the mean population of C. jejuni was reduced to less than 10 CFU/ml (detected only by enrichment for 48 h) after 10-s treatment. The diluted chlorine water (25 mg/l residual chlorine) was less effective than the diluted EO water for inactivation of C. jejuni. EO water was further evaluated for its effectiveness in reducing C. jejuni on chicken during washing. EO water treatment was equally effective as chlorinated water and both achieved reduction of C. jejuni by about 3 log10 CFU/g on chicken, whereas deionized water (control) treatment resulted in only 1 log10 CFU/g reduction. No viable cells of C. jejuni were recovered in EO and chlorinated water after washing treatment, whereas high populations of C. jejuni (4 log10 CFU/ml) were recovered in the wash solution after the control treatment. Our study demonstrated that EO water was very effective not only in reducing the populations of C. jejuni on chicken, but also could prevent cross-contamination of processing environments.

PMID: 11843416 [PubMed - indexed for MEDLINE]

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45. Prediction of microbial growth in fresh-cut vegetables treated with acidic electrolyzed water during storage under various temperature conditions.

J Food Prot. 2001 Dec;64(12):1935-42. **Koseki S** , **Itoh K** .

Graduate School of Agriculture, Hokkaido University, Sapporo, Japan. koseki@bpe.agr.hokudai.ac.jp

Effects of storage temperature (1, 5, and 10 degrees C) on growth of microbial populations (total aerobic bacteria, coliform bacteria, Bacillus cereus, and psychrotrophic bacteria) on acidic electrolyzed water (AcEW)-treated fresh-cut lettuce and cabbage were determined. A modified Gompertz function was used to describe the kinetics of microbial growth. Growth data were analyzed using regression analysis to generate "best-fit" modified Gompertz equations, which were subsequently used to calculate lag time, exponential growth rate, and generation time. The data indicated that the growth kinetics of each bacterium were dependent on storage temperature, except at 1 degrees C storage. At 1 degrees C storage, no increases were observed in bacterial populations. Treatment of vegetables with AcEW produced a decrease in initial microbial populations. However, subsequent growth rates were higher than on nontreated vegetables. The recovery time required by the reduced microbial population to reach the initial (treated with tap water [TW]) population was also determined in this study, with the recovery time of the microbial population at 10 degrees C being <3 days. The benefits of reducing the initial microbial populations on fresh-cut vegetables were greatly affected by storage temperature. Results from this study could be used to predict microbial quality of fresh-cut lettuce and cabbage throughout their distribution.

PMID: 11770620 [PubMed - indexed for MEDLINE]

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46. Effects of storage conditions and pH on chlorine loss in electrolyzed oxidizing (EO) water.

J Agric Food Chem. 2002 Jan 2;50(1):209-12. **Len SV** , **Hung YC** , **Chung D** , **Anderson JL** , **Erickson MC** ,**Morita K** .

Department of Food Science and Technology, University of Georgia, Griffin, GA 30223-1797, USA.

The chlorine loss of electrolyzed oxidizing (EO) water was examined during storage under different light, agitation, and packaging conditions. The chlorine loss of pH-adjusted EO water was also examined. Under open conditions, the chlorine loss through evaporation followed first-order kinetics. The rate of chlorine loss was increased about 5-fold with agitation, but it was not significantly affected by diffused light. Under closed conditions, the chlorine loss did not follow first-order kinetics, because the primary mechanism of chlorine loss may be self-decomposition of chlorine species rather than chlorine evaporation. The effect of diffused light was more significant compared to agitation after two months of storage under closed conditions. The chlorine loss of EO water and commercial chlorinated water decreased dramatically with the increase of pH from the acidic (pH 2.5) to the alkaline (pH 9.0) region.

PMID: 11754569 [PubMed - indexed for MEDLINE]

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47. Application of electrolyzed acid water to sterilization of denture base part 1. Examination of sterilization effects on resin plate.

Dent Mater J. 2001 Jun;20(2):148-55.

Nagamatsu Y , **Tajima K** , **Kakigawa H** , **Kozono Y** .

Department of Materials Science, Kyushu Dental College, Kokurakita, Kitakyushu, Japan.

Bactericidal activities of electrolyzed strong and weak acid waters for acrylic denture base resin were evaluated in order to discuss the applicability of these waters for sterilization of denture base. Only 1-minute immersion in the electrolyzed strong or weak acid water could completely eliminate the attached bacteria, Staphylococcus aureus 209P, on the resin plate. When the resin was relined with tissue conditioner, 5-minute immersion or 1- to 2-minute ultrasonic cleaning reduced the number of the bacteria from 10(5)/cm2 level to 10(1)/cm2 and no surviving bacteria could be detected after 10-minute treatment. These findings suggest that both the electrolyzed strong and weak acid waters are well applicable to the disinfectant for acrylic denture base showing excellent bactericidal activities in a significantly shorter treatment as compared with the conventional denture cleaning.

PMID: 11523978 [PubMed - indexed for MEDLINE]

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48. Decontamination of lettuce using acidic electrolyzed water.

J Food Prot. 2001 May;64(5):652-8.

Koseki S , **Yoshida K** , **Isobe S** , **Itoh K** .

Graduate School of Agricultural Science, Hokkaido University, Sapporo, Japan. koseki@bpe.agr.hokudai.ac.jp

The disinfectant effect of acidic electrolyzed water (AcEW), ozonated water, and sodium hypochlorite (NaOCl) solution on lettuce was examined. AcEW (pH 2.6; oxidation reduction potential, 1140 mV; 30 ppm of available chlorine) and NaOCl solution (150 ppm of available chlorine) reduced viable aerobes in lettuce by 2 log CFU/g within 10 min. For lettuce washed in alkaline electrolyzed water (AIEW) for 1 min and then disinfected in AcEW for 1 min, viable aerobes were reduced by 2 log CFU/g. On the other hand, ozonated water containing 5 ppm of ozone reduced viable aerobes in lettuce 1.5 log CFU/g within 10 min. It was discovered that AcEW showed a higher disinfectant effect than did ozonated water significantly at $P < 0.05$. It was confirmed by swabbing test that AcEW, ozonated water, and NaOCI solution removed aerobic bacteria, coliform bacteria, molds, and yeasts on the surface of lettuce. Therefore, residual microorganisms after the decontamination of lettuce were either in the inside of the cellular tissue, such as the stomata, or making biofilm on the surface of lettuce. Biofilms were observed by a scanning electron microscope on the surface of the lettuce treated with AcEW. Moreover, it was shown that the spores of bacteria on the surface were not removed by any treatment in this study. However, it was also observed that the surface structure of lettuce was not damaged by any treatment in this study. Thus, the use of AcEW for decontamination of fresh lettuce was suggested to be an effective means of controlling microorganisms.

PMID: 11347995 [PubMed - indexed for MEDLINE]

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50. Effect of electrolyzed water on wound healing.

Artif Organs. 2000 Dec;24(12):984-7.

Yahagi N , **Kono M** , **Kitahara M** , **Ohmura A** , **Sumita O** , **Hashimoto T** , **Hori K** , **Ning-Juan C** , **Woodson P** , **Kubota S** , **Murakami A** , **Takamoto S** .

Department of Anesthesiology, Teikyo University Mizonokuchi Hospital, Tokyo, Japan. naokiyah@aol.com

Electrolyzed water accelerated the healing of full-thickness cutaneous wounds in rats, but only anode chamber water (acid pH or neutralized) was effective. Hypochlorous acid (HOCl), also produced by electrolysis, was ineffective, suggesting that these types of electrolyzed water enhance wound healing by a mechanism unrelated to the well-known antibacterial action of HOCl. One possibility is that reactive oxygen species, shown to be electron spin resonance spectra present in anode chamber water, might trigger early wound healing through fibroblast migration and proliferation.

PMID: 11121980 [PubMed - indexed for MEDLINE]

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51. The use of electrolyzed solutions for the cleaning and disinfecting of dialyzers.

Artif Organs. 2000 Dec;24(12):921-8. **Tanaka N** , **Tanaka N** , **Fujisawa T** , **Daimon T** , **Fujiwara K** ,**Yamamoto M** , **Abe T** .

Kiyokai Tanaka-Kitanoda Hospital, Sakai-shi, Osaka, Japan.

Recently, the use of electrolyzed solutions has attracted considerable interest in Japan. This study investigates the efficiency of electrolyzed solutions as disinfecting agents (DA) in the reuse of dialyzers and compares their efficiency to that of other disinfectants currently in use. The following 3 methods were employed. First, the rinsing time and rebound release of reused dialyzers were measured and compared after electrolyzed solutions, electrolyzed strong acid aqueous solution (ESAAS) and electrolyzed strong basic aqueous solution (ESBAS), made from reverse osmosis (RO) water (ESAAS, ESBAS; Generating apparatuses: Super Oxseed alpha 1000, Amano Corporation, Yokohama, Japan), 2% Dialox-cj (Teijin Gambro Medical, Tokyo, Japan), and 3.8% formalin were used as DAs. This involved performing dialysis with 2 types of dialyzers: a cellulose acetate membrane (CAM) dialyzer and a polysulfone membrane (PSM) dialyzer. The dialyzers were cleaned and disinfected using the different DA and left for 48 h. Next, after performing dialysis the dialyzer membranes were cleaned with a saline solution (0.9% NaCl) and RO water and then cleaned with the various DA. These membranes were observed using a scanning electron microscope (SEM) to check for the presence of physical and biological contaminants. Finally, in vitro tests were performed to determine the level of dialyzer clearance when PSM dialyzers were reused after having been cleaned and disinfected with the electrolyzed solutions. The rinsing time results for both the CAM and PSM dialyzers showed the electrolyzed solutions (ESBAS and ESAAS) as being undetectable within 10 min. With regard to the rebound release, for both the CAM and PSM dialyzers, the electrolyzed solutions were undetectable at all checking times between 30 and 240 min. Observation by SEM showed that cleaning with both ESAAS and ESBAS left the fewest contaminants, and cleaning with 2% Dialox-cj left the highest level of contaminants in the CAM dialyzers. With regard to experiments concerning use in vitro, no major changes in the dialyzer clearance were noticed after 6 uses. In every experiment, the previous investigations showed the electrolyzed solutions to be superior to 3. 8% formalin and 2% Dialox-cj DA for the reuse of dialyzers.

PMID: 11121970 [PubMed - indexed for MEDLINE]

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52. Ultraviolet spectrophotometric characterization and bactericidal properties of electrolyzed oxidizing water as influenced by amperage and pH.

J Food Prot. 2000 Nov;63(11):1534-7.

Len SV , **Hung YC** , **Erickson M** , **Kim C** .

Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.

To identify the primary component responsible in electrolyzed oxidizing (EO) water for inactivation, this study determined the concentrations of hypochlorous acid (HOCl) and hypochlorite ions (OCl-) and related those concentrations to the microbicidal activity of the water. The ultraviolet absorption spectra were used to determine the concentrations of HOCl and OCl- in EO water and the chemical equilibrium of these species with change in pH and amperage. EO water generated at

higher amperage contained a higher chlorine concentration. The maximum concentration of HOCl was observed around pH 4 where the maximum log reduction (2.3 log10 CFU/ml) of Bacillus cereus F4431/73 vegetative cells also occurred. The high correlation (r = 0.95) between HOCl concentrations and bactericidal effectiveness of EO water supports HOCl's role as the primary inactivation agent. Caution should be taken with standard titrimetric methods for measurement of chlorine as they cannot differentiate the levels of HOCl present in EO water of varying pHs.

PMID: 11079696 [PubMed - indexed for MEDLINE]

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53. Efficacy of electrolyzed oxidizing (EO) and chemically modified water on different types of foodborne pathogens.

Int J Food Microbiol. 2000 Nov 1;61(2-3):199-207.

Kim C , **Hung YC** , **Brackett RE** .

Center for Food Safety and Quality Enhancement, Department of Food Science and Technology, College of Agricultural anid Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.

This study was undertaken to evaluate the efficacy of electrolyzed oxidizing (EO) and chemically modified water with properties similar to the EO water for inactivation of different types of foodborne pathogens (Escherichia coli O157:H7, Listeria monocytogenes and Bacillus cereus). A five-strain cocktail of each microorganism was exposed to deionized water (control), EO water and chemically modified water. To evaluate the effect of individual properties (pH, oxidation-reduction potential (ORP) and residual chlorine) of treatment solutions on microbial inactivation, iron was added to reduce ORP readings and neutralizing buffer was added to neutralize chlorine. Inactivation of E. coli O157:H7 occurred within 30 s after application of JAW EO water with 10 mg/l residual chlorine and chemically modified solutions containing 13 mg/l residual chlorine. Inactivation of Gram-positive and -negative microorganisms occurred within 10 s after application of ROX EO water with 56 mg/l residual chlorine and chemically modified solutions containing 60 mg/l residual chlorine. B. cereus was more resistant to the treatments than E. coli O157:H7 and L. monocytogenes and only 3 log10 reductions were achieved after 10 s of ROX EO water treatment. B. cereus spores were the most resistant pathogen. However, more than 3 log10 reductions were achieved with 120-s EO water treatment.

PMID: 11078171 [PubMed - indexed for MEDLINE]

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54. Effectiveness of electrolyzed oxidized water irrigation in a burn-wound infection model.

J Trauma. 2000 Sep;49(3):511-4.

Nakae H , **Inaba H** .

Department of Emergency and Critical Care Medicine, Akita University School of Medicine, Japan.

OBJECTIVE: The purpose of the study was to determine whether electrolyzed oxidized water (EOW) functions as a bactericide in burn injury with Pseudomonas aeruginosa infection in a rat burn-wound model. METHODS: Anesthetized Sprague-Dawley rats (n = 31) were subjected to third-degree burns to 30% of total body surface area. Two days after injury, all rats were infected with P. aeruginosa using 1 mL of a suspension containing 1 x 10(8) colony-forming units. Rats were assigned to one of three groups: no irrigation (group I), irrigation with physiologic saline (group II), or irrigation with EOW (group III). Blood culture, endotoxin levels, and survival rates were determined. RESULTS: Survival rate was significantly higher in group III than in groups I or II ($p < 0.0001$). Serum endotoxin levels on day 3 after infection in group III were significantly lower than the levels in group I ($p < 0.01$) and group II ($p < 0.01$). There were significant differences between the three groups in the culture of P. aeruginosa ($p < 0.05$). CONCLUSION: Irrigation and disinfection with EOW may become useful in preventing burn-wound sepsis.

PMID: 11003331 [PubMed - indexed for MEDLINE]

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55. Disinfection potential of electrolyzed solutions containing sodium chloride at low concentrations.

J Virol Methods. 2000 Mar;85(1-2):163-74.

Morita C , **Sano K** , **Morimatsu S** , **Kiura H** , **Goto T** , **Kohno T** , **Hong WU** , **Miyoshi H** , **Iwasawa A** ,**Nakamura Y** , **Tagawa M** , **Yokosuka O** , **Saisho H** , **Maeda T** , **Katsuoka Y** .

Department of Microbiology, Osaka Medical College, Japan.

Electrolyzed products of sodium chloride solution were examined for their disinfection potential against hepatitis B virus (HBV) and human immunodeficiency virus (HIV) in vitro. Electrolysis of 0.05% NaCl in tap water was carried out for 45 min at room temperature using a 3 A electric current in separate wells installed with positive and negative electrodes. The electrolyzed products were obtained from the positive well. The oxidation reduction potential (ORP), pH and free chlorine content of the product were 1053 mV, pH 2.34 and 4.20 ppm, respectively. The products modified the antigenicity of the surface protein of HBV as well as the infectivity of HIV in time- and concentration-dependent manner. Although the inactivating potential was decreased by the addition of contaminating protein, recycling of the product or continuous addition of fresh product may restore the complete disinfection against bloodborne pathogens.

PMID: 10716349 [PubMed - indexed for MEDLINE]

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56. Newer technologies for endoscope disinfection: electrolyzed acid water and disposable-component endoscope systems.

Gastrointest Endosc Clin N Am. 2000 Apr;10(2):319-28.

Nelson D .

Department of Gastroenterology, Minneapolis Veterans Affairs Medical Center, Minnesota 55417, USA.

Novel technologies have been designed to improve or replace more conventional methods of endoscope disinfection. Electrolyzed acid water has the potential to decrease the time, toxicity, and cost of endoscope disinfection. Disposable-component endoscope systems have the potential to improve the ease of cleaning and disinfection, or eliminate the need altogether.

Publication Types:

- Review

PMID: 10683217 [PubMed - indexed for MEDLINE]

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57. Roles of oxidation-reduction potential in electrolyzed oxidizing and chemically modified water for the inactivation of food-related pathogens.

J Food Prot. 2000 Jan;63(1):19-24.

Kim C , **Hung YC** , **Brackett RE** .

Center for Food Safety and Quality Enhancement, Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin 30223-1797, USA.

This study investigates the properties of electrolyzed oxidizing (EO) water for the inactivation of pathogen and to evaluate the chemically modified solutions possessing properties similar to EO water in killing Escherichia coli O157:H7. A five-strain cocktail (10(10) CFU/ml) of E. coli O157:H7 was subjected to deionized water (control), EO water with 10 mg/liter residual chlorine (J.A.W-EO water), EO water with 56 mg/liter residual chlorine (ROX-EO water), and chemically modified solutions. Inactivation (8.88 log10 CFU/ml reduction) of E. coli O157:H7 occurred within 30 s after application of EO water and chemically modified solutions containing chlorine and 1% bromine. Iron was added to EO or chemically modified solutions to reduce oxidation-reduction potential (ORP) readings and neutralizing buffer was added to neutralize chlorine. J.A.W-EO water with 100 mg/liter iron, acetic acid solution, and chemically modified solutions containing neutralizing buffer or 100 mg/liter iron were ineffective in reducing the bacteria population. ROX-EO water with 100 mg/liter iron was the only solution still effective in inactivation of E. coli O157:H7 and having high ORP readings regardless of residual chlorine. These results suggest that it is possible to simulate EO water by chemically modifying deionized water and ORP of the solution may be the primary factor affecting microbial inactivation.

PMID: 10643764 [PubMed - indexed for MEDLINE]

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58. Cytotoxicity and microbicidal activity of electrolyzed strong acid water and acidic hypochlorite solution under isotonic conditions.

Kansenshogaku Zasshi. 1999 Oct;73(10):1025-31.

Okubo K , **Urakami H** , **Tamura A** .

Department of Pharmacy, Koseiren Murakami General Hospital, Murakami City, Japan.

The cytotoxic effects of electrolyzed strong acid water and acidic hypochlorite solution, as well as these solutions after isotonization, against cultivated L cells were compared along with their microbicidal activities. Isotonization was accompanied by a reduction in the cytotoxic effects of these solutions against L cells. Microbicidal activity was also reduced somewhat but was still retained after isotonization. No difference was observed in these properties between these antiseptic solutions. The results obtained indicate that acidic hypochlorite solution may be useful as well as acidic electrolyzed water.

PMID: 10565117 [PubMed - indexed for MEDLINE]

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59. Effectiveness of acidic oxidative potential water in preventing bacterial infection in islet transplantation.

Cell Transplant. 1999 Jul-Aug;8(4):405-11.

Miyamoto M , **Inoue K** , **Gu Y** , **Hoki M** , **Haji S** , **Ohyanagi H** .

Department of Organ Reconstruction, Institute for Frontier Medical Sciences, Kyoto University, Japan.

At a number of points in the current procedures of islet isolation and islet culture after the harvesting of donor pancreata, microorganisms could potentially infect the islet preparation. Furthermore, the use of islets from multiple donors can compound the risks of contamination of individual recipients. Acidic oxidative potential water (also termed electrolyzed strong acid solution, function water, or acqua oxidation water), which was developed in Japan, is a strong acid formed on the anode in the electrolysis of water containing a small amount of sodium chloride. It has these physical properties: pH, from 2.3 to 2.7; oxidative-reduction potential, from 1,000 to 1,100 mV; dissolved chlorine, from 30 to 40 ppm; and dissolved oxygen, from 10 to 30 ppm. Because of these properties, acidic oxidative potential water has strong bactericidal effects on all bacteria including methicillin-resistant Staphylococcus aureus (MRSA), viruses including HIV, HBV, HCV, CMV, and fungi as a result of the action of the active oxygen and active chlorine that it contains. We conducted this study to evaluate the effect of acidic oxidative potential water irrigation on bacterial contamination on the harvesting of porcine pancreata from slaughterhouses for islet xenotransplantation by counting the number of pancreatic surface bacteria using the Dip-slide method, and on the results of islet culture; and to evaluate the direct effect on isolated islets when it is used to prevent bacterial contamination by the static incubation test and by morphological examination. Direct irrigation of the pancreas by acidic oxidative potential water was found to be very effective in preventing bacterial contamination, but direct irrigation of isolated islets slightly decreased their viability and function.

PMID: 10478721 [PubMed - indexed for MEDLINE]

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60. Efficacy of electrolyzed oxidizing water for inactivating Escherichia coli O157:H7, Salmonella enteritidis, and Listeria monocytogenes.

Appl Environ Microbiol. 1999 Sep;65(9):4276-9.

Venkitanarayanan KS , **Ezeike GO** , **Hung YC** , **Doyle MP** .

Department of Animal Science, University of Connecticut, Storrs, Connecticut 06269, USA.

The efficacy of electrolyzed oxidizing water for inactivating Escherichia coli O157:H7, Salmonella enteritidis, and Listeria monocytogenes was evaluated. A five-strain mixture of E. coli O157:H7, S. enteritidis, or L. monocytogenes of approximately 10(8) CFU/ml was inoculated in 9 ml of electrolyzed oxidizing water (treatment) or 9 ml of sterile, deionized water (control) and incubated at 4 or 23 degrees C for 0, 5, 10, and 15 min; at 35 degrees C for 0, 2, 4, and 6 min; or at 45 degrees C for 0, 1, 3, and 5 min. The surviving population of each pathogen at each sampling time was determined on tryptic soy agar. At 4 or 23 degrees C, an exposure time of 5 min reduced the populations of all three pathogens in the treatment samples by approximately 7 log CFU/ml, with complete inactivation by 10 min of exposure. A reduction of >/=7 log CFU/ml in the levels of the three pathogens occurred in the treatment samples incubated for 1 min at 45 degrees C or for 2 min at 35 degrees C. The bacterial counts of all three pathogens in control samples remained the same throughout the incubation at all four temperatures. Results indicate that electrolyzed oxidizing water may be a useful disinfectant, but appropriate applications need to be validated.

PMID: 10473453 [PubMed - indexed for MEDLINE]

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61. Inactivation of Escherichia coli O157:H7 and Listeria monocytogenes on plastic kitchen cutting boards by electrolyzed oxidizing water.

J Food Prot. 1999 Aug;62(8):857-60.

Venkitanarayanan KS , **Ezeike GO** , **Hung YC** , **Doyle MP** .

Department of Animal Science, University of Connecticut, Storrs 06269, USA.

One milliliter of culture containing a five-strain mixture of Escherichia coli O157:H7 (approximately 10(10) CFU) was inoculated on a 100-cm2 area marked on unscarred cutting boards. Following inoculation, the boards were air-dried under a laminar flow hood for 1 h, immersed in 2 liters of electrolyzed oxidizing water or sterile deionized water at 23 degrees C or 35 degrees C for 10 or 20 min; 45 degrees C for 5 or 10 min; or 55 degrees C for 5 min. After each temperature-time combination, the surviving population of the pathogen on cutting boards and in soaking water was determined. Soaking of

inoculated cutting boards in electrolyzed oxidizing water reduced E. coli O157:H7 populations by > or = 5.0 log CFU/100 cm2 on cutting boards. However, immersion of cutting boards in deionized water decreased the pathogen count only by 1.0 to 1.5 log CFU/100 cm2. Treatment of cutting boards inoculated with Listeria monocytogenes in electrolyzed oxidizing water at selected temperature-time combinations (23 degrees C for 20 min, 35 degrees C for 10 min, and 45 degrees C for 10 min) substantially reduced the populations of L. monocytogenes in comparison to the counts recovered from the boards immersed in deionized water. E. coli O157:H7 and L. monocytogenes were not detected in electrolyzed oxidizing water after soaking treatment, whereas the pathogens survived in the deionized water used for soaking the cutting boards. This study revealed that immersion of kitchen cutting boards in electrolyzed oxidizing water could be used as an effective method for inactivating foodborne pathogens on smooth, plastic cutting boards.

PMID: 10456736 [PubMed - indexed for MEDLINE]

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62. Bactericidal effect of electrolyzed neutral water on bacteria isolated from infected root canals. 64. The physiological property and function of the electrolyzed-ionized calcium Aquamax on water molecular clusters fractionization.

Artif Organs. 1997 Jan;21(1):43-9.

Hatto M , **Sakai Y** , **Ohtsuka H** .

Aquamax Co., Ltd., Tokyo, Japan.

Aquamax, the ionized mineral (Ca, 21 mg/ml; MG, 0.068 mg/ml; Na 0.13 mg/ml; K, 0.006 mg/ml) is a fermented organic mineral extract. The fundamental physiological property and function of this mineral is to promote the molecular level mineral supply to the cell inside. The contained minerals exist at a molecular level to fractionize the molecular clusters of water and to make water's penetration ratio into objects higher only at 0.1-0.2% concentration. Existing minerals, especially the calcium, were barely dissolved in water, and its low penetration was caused by its low electrolyzed behavior plus the effects from an anion mineral, such as phosphorous, sulfur, nitrogen, or any oxalic acid combining with a colloidal calcium to construct and crystallize as the calcium phosphate and the calcium sulfate. Aquamax minerals penetrate into objects to fractionize water molecular clusters and to make water functional, neutralize in the anion mineral and oxalic acid elements, raise the object's electric conductivity, and preserve perishables.

PMID: 9012906 [PubMed - indexed for MEDLINE]

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65. Trial of electrolyzed strong acid aqueous solution lavage in the treatment of peritonitis and intraperitoneal abscess.

Artif Organs. 1997 Jan;21(1):28-31

Inoue Y , **Endo S** , **Kondo K** , **Ito H** , **Omori H** , **Saito K** .

Critical Care and Emergency Center, Iwate Medical University, Morioka, Japan.

Electrolyzed strong acid aqueous solution is acidic water that contains active oxygen and active chlorine and possesses a redox potential. We performed peritoneal and abscess lavages with an electrolyzed strong acid aqueous solution to treat 7 patients with peritonitis and intraperitoneal abscesses, who were seen in our department between December 1994 and April 1995. The underlying disease was duodenal ulcer perforation in 4 of these 7 patients and gastric ulcer perforation, acute enteritis, and intraperitoneal perforation of pyometrium in 1 patient each. Irrigation was performed twice a day. Microbiological studies of the paracentesis fluid were negative in 3 cases, and the irrigation period was 2-4 days. Anaerobic bacteria were isolated in 3 of the 4 positive cases (Bacteroides in 2, Prevotella in 1), and a fungus (Candida) was isolated in the remaining patient. The period of irrigation in these patients ranged from 9 to 12 days, but conversion to a microorganism negative state was observed in 3-7 days.

Publication Types:

- Clinical Trial

PMID: 9012903 [PubMed - indexed for MEDLINE]

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66. Bactericidal effect of acidic electrolyzed water--comparison of chemical acidic sodium hydrochloride (NaOCl) solution

Kansenshogaku Zasshi. 1996 Sep;70(9):915-22. [Article in Japanese]

Iwasawa A , **Nakamura Y** .

Department of Clinical Pathology, Showa University Fujigaoka Hospital, Kanagawa.

Acidic electrolyzed water is made recently by various kinds of machines and is widely utilized. In this study, we intended to clarify the relationship between the concentration of chloride and pH in the bactericidal effects with acidic electrolyzed water. The effects of weak or strong acidic electrolyzed water were compared with a pseudo-acidic water of pH adjusted by diluted hydrochloric acid and sodium hydroxide, on Staphylococcus aureus, Staphylococcus epidermidis and Pseudomononas aeruginosa. At pH 5.0 approximately 6.0, 3 bacterial strains were killed soon after being exposed to the acidic water containing chloride 50 mg/liter, and the amount of chloride did not change after allowing to stand open for 6 hours. At pH 2.67 approximately 2.80, the bactericidal effects was observed at the concentration of chloride 5 mg/liter, and 80% of chloride remained after allowing to stand for 6 hours. These results indicated that newly made strong acidic water is more effective under a smaller amount of chloride at pH 2.7, and that weak acidic electrolyzed water should be used, if stable bactericidal effect is expected in cleaning the surroundings.

PMID: 8921674 [PubMed - indexed for MEDLINE]

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67. Preliminary study of microbiocide effect and its mechanism of electrolyzed oxidizing water

Zhonghua Liu Xing Bing Xue Za Zhi. 1996 Apr;17(2):95-8. [Article in Chinese]

Li XW , **Sun SH** , **Li T** .

Institute of Epidemiology and Microbiology, Chinese Academy of Preventive Medicine, Beijing.

Electrolyzed Oxidizing water (EO Water) is characterized by possessing higher oxidizing reduction potential (ORP), lower pH value and oxidizing potential. Under conditions of free organic matter, it was tested for microbiocide efficacy in laboratory. The results showed that EO water could completely kill all of the staphylococcus aureus and E. coli within 15 seconds, while for completely killing of spores of Bacillus subtilis Var. niger it would take 10 min. When it was used to destroy the antigenicity of HBsAg, 30 seconds was needed. The ORP and pH values of EO water were not obviously changed when stored in room-temperature with, airtight and light-free conditions for three weeks. Distilled water and physiological saline had little influence on the ORP and pH value of EO water, but organic matters and phosphates had greater influence upon the two values.

PMID: 8758404 [PubMed - indexed for MEDLINE]

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68. Effect of rinsing hydrocolloid impressions using acidic electrolyzed water on surface roughness and surface hardness of stone models.

J Oral Sci. 2002 Dec;44(3-4):141-6.

Nakagawa H , **Hiraguchi H** , **Uchida H** , **Tanabe N** .

Laboratory of Dental Materials Research, Division of Biomaterials Science, Dental Research Center, Nihon University School of Dentistry, Tokyo 101-8310, Japan. nakagawa@dent.nihon-u.ac.jp

The present study investigated the effect on the surface quality of resultant stone models of rinsing hydrocolloid impressions using acidic electrolyzed water. Two brands of alginate impression materials (Aroma Fine DFIII, Jeltrate Plus), an agar impression material (Ajisai) designed for agar/alginate combined impression, and dental stone (New Plastone) were used to make the test specimens. For the rinsing of impressions, acidic electrolyzed water having a pH value of 2.3, an oxidation-reduction potential of 1,230 mV, and a residual chlorine concentration of 45.0 ppm, was prepared. Alginate, agar and agar/alginate combined impressions were rinsed using acidic electrolyzed water or tap water for 30 sec and 3 min, and as a control, these impressions were not rinsed with any water. Disk-shaped stone specimens obtained from rinsed impressions were evaluated with respect to surface roughness (Ra) and surface hardness (scratch depth), and scanning electron microscope (SEM) observations were performed. The stone specimens obtained from rinsed impressions using acidic electrolyzed water showed a surface quality equivalent to that of the stone specimens obtained from the rinsed impression using tap water. This result suggests that the use of acidic electrolyzed water for rinsing is an acceptable treatment for hydrocolloid impressions, so long as the rinsing time is from 30 sec to 3 min.

PMID: 12613503 [PubMed - indexed for MEDLINE]

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69. Bactericidal effect of electrolyzed neutral water on bacteria isolated from infected root canals.

Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999 Jan;87(1):83-7.

Horiba N, Hiratsuka K, Onoe T, Yoshida T, Suzuki K, Matsumoto T, Nakamura H.

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OBJECTIVE: The purposes of this study were to examine the time-related changes in pH, oxidation-reduction potential, and concentration of chlorine of electrolyzed neutral water and to evaluate the bactericidal effect of electrolyzed neutral water against bacteria from infected root canals. STUDY DESIGN: Various properties of electrolyzed neutral water--pH value, oxidation-reduction potential, and concentration of chlorine--were measured at different times after storage of the water in the open state, the closed state, or the closed-and-dark state. The bactericidal effect of the various electrolyzed neutral water samples was then tested against 17 strains of bacteria, including 15 strains isolated from infected canals, as well as against 1 strain of fungus. Each bacterial or fungal suspension was mixed with electrolyzed neutral water, and the 2 substances were reacted together for 1 minute. After incubation for 1 to 7 days, the bactericidal effect of the electrolyzed neutral water was determined. RESULTS: The pH value and oxidation-reduction potential of electrolyzed neutral water remained almost unchanged when the water was stored in a dark, closed container. However, the concentration of chlorine decreased from 18.4 ppm to 10.6 ppm. Electrolyzed neutral water showed a bactericidal or growth-inhibitory effect against the bacteria. CONCLUSIONS: The results indicate that electrolyzed neutral water maintains a constant pH and oxidation-reduction potential when kept in a closed container without light and that it exhibits a bacteriostatic/bactericidal action against isolates obtained from infected root canals.

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[Editors Note: this study is not about ionized water. I have included it as it is very relevant to the topic. Cola's are just acid and sugar waters. JK]

70. Cola beverage consumption induces bone mineralization reduction in ovariectomized rats.

Arch Med Res. 2000 Jul-Aug;31(4):360-5. **Garcia-Contreras F** , **Paniagua R** , **Avila-Diaz M** , **Cabrera-Munoz L** , **Martinez-Muniz I** , **Foyo-Niembro E** , **Amato D** .

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BACKGROUND: A significant association of cola beverage consumption and increased risk of bone fractures has been recently reported. The present study was carried out to examine the relationship of cola soft drink intake and bone mineral density in ovariectomized rats. METHODS: Study 1. Four groups of 10 female Sprague-Dawley rats were studied. Animals from groups II, III, and IV were bilaterally ovariectomized. Animals from groups I and II received tap water for drinking, while animals from groups III and IV each drank a different commercial brand of cola soft drink. After 2 months on these diets, the following were measured: solid diet and liquid consumption; bone mineral density; calcium in bone ashes; femoral cortex width; calcium; phosphate; albumin; creatinine; alkaline phosphatase; 25-OH hydroxyvitamin D, and PTH. RESULTS: Study 2. Two groups of seven ovariectomized rats were compared. Group A animals received the same management as the group III animals from study 1 (cola soft drink and rat chow ad libitum), while rats from group B received tap water for drinking and pair-feeding. After 2 months plasmatic ionized calcium, phosphate, creatinine, albumin, calcium in femoral ashes, and femoral cortex width were measured.Study 1. Rats consuming cola beverages (groups III and IV) had a threefold higher liquid intake than rats consuming water (groups I and II). Daily solid food intake of rats consuming cola soft drinks was one-half that of rats consuming water. Rats consuming soft drinks developed hypocalcemia and their femoral mineral density measured by DEXA was significantly lower than control animals as follows: group I, 0.20 +/- 0.02; group II, 0.18 +/- 0.01; group III, 0.16 +/- 0.01, and group IV, 0.16 +/- 0.01 g/cm(2). Study 2. To rule out the possibility that these calcium and bone mineral disorders were caused by decreased solid food intake, a pair-fed group was studied. Despite a lower body weight, pair-fed animals consuming tap water did not develop bone mineral reduction or hypocalcemia. CONCLUSIONS: These data suggest that heavy intake of cola soft drinks has the potential of reducing femoral mineral density.

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71. Treatment of Escherichia coli (O157:H7) inoculated alfalfa seeds and sprouts with electrolyzed oxidizing water.

Int J Food Microbiol.
2003 Sep 15;86(3):231-7.

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Electrolyzed oxidizing water is a relatively new concept that has been utilized in agriculture, livestock management, medical sterilization, and food sanitation. Electrolyzed oxidizing (EO) water generated by passing sodium chloride solution through an EO water generator was used to treat alfalfa seeds and sprouts inoculated with a five-strain cocktail of nalidixic acid resistant Escherichia coli O157:H7. EO water had a pH of 2.6, an oxidation-reduction potential of 1150 mV and about 50 ppm free chlorine. The percentage reduction in bacterial load was determined for reaction times of 2, 4, 8, 16, 32, and 64 min. Mechanical agitation was done while treating the seeds at different time intervals to increase the effectiveness of the treatment. Since E. coli O157:H7 was released due to soaking during treatment, the initial counts on seeds and sprouts were determined by soaking the contaminated seeds/sprouts in 0.1% peptone water for a period equivalent to treatment time. The samples were then pummeled in 0.1% peptone water and spread plated on tryptic soy agar with 5 microg/ml of nalidixic acid (TSAN). Results showed that there were reductions between 38.2% and 97.1% (0.22-1.56 log(10) CFU/g) in the bacterial load of treated seeds. The reductions for sprouts were between 91.1% and 99.8% (1.05-2.72 log(10) CFU/g). An increase in treatment time increased the percentage reduction of E. coli O157:H7. However, germination of the treated seeds reduced from 92% to 49% as amperage to make EO water and soaking time increased. EO water did not cause any visible

damage to the sprouts.
PMID: 12915034 [PubMed - indexed for MEDLINE]

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72. Comparison of electrolyzed oxidizing water with various antimicrobial interventions to reduce Salmonella species on poultry.

Poult Sci. 2002 Oct;81(10):1598-605.

Fabrizio KA, Sharma RR, Demirci A, Cutter CN.

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Foodborne pathogens in cell suspensions or attached to surfaces can be reduced by electrolyzed oxidizing (EO) water; however, the use of EO water against pathogens associated with poultry has not been explored. In this study, acidic EO water [EO-A; pH 2.6, chlorine (CL) 20 to 50 ppm, and oxidation-reduction potential (ORP) of 1,150 mV], basic EO water (EO-B; pH 11.6, ORP of -795 mV), CL, ozonated water (OZ), acetic acid (AA), or trisodium phosphate (TSP) was applied to broiler carcasses inoculated with Salmonella Typhimurium (ST) and submerged (4 C, 45 min), spray-washed (85 psi, 25 C, 15 s), or subjected to multiple interventions (EO-B spray, immersed in EO-A; AA or TSP spray, immersed in CL). Remaining bacterial populations were determined and compared at Day 0 and 7 of aerobic, refrigerated storage. At Day 0, submersion in TSP and AA reduced ST 1.41 log10, whereas EO-A water reduced ST approximately 0.86 log10. After 7 d of storage, EO-A water, OZ, TSP, and AA reduced ST, with detection only after selective enrichment. Spray-washing treatments with any of the compounds did not reduce ST at Day 0. After 7 d of storage, TSP, AA, and EO-A water reduced ST 2.17, 2.31, and 1.06 log10, respectively. ST was reduced 2.11 log10 immediately following the multiple interventions, 3.81 log10 after 7 d of storage. Although effective against ST, TSP and AA are costly and adversely affect the environment. This study demonstrates that EO water can reduce ST on poultry surfaces following extended refrigerated storage.

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73. Effects of water flow rate, salt concentration and water temperature on efficiency of an electrolyzed oxidizing water generator

Journal of Food Engineering, Volume 60, Issue 4, December 2003, Pages 469-473
S. Y. Hsu

A three-factor central composite design was adopted to investigate the effects of water flow rate, water temperature and salt concentration on electrolysis efficiency and separation efficiency of an electrolyzed oxidizing water generator. Results indicated that electric potential (7.9–15.7 V) and power consumption (16–120 W) of the electrolysis cell were not affected by water flow rate, water temperature or salt concentration in the feed solution. Electric current of the cells changed in between two levels (7.41 ± 0.1 and 7.68 ± 0.1 A) depending on water temperature and water flow rate. Electrolysis efficiency of the electrolysis cell, represented by the reduction ratio of chloride ions, varied in the range of 23–51%.

Separation efficiency of the cation ion-exchange membrane, represented by the reduction ratio of sodium ions, varied in the range of 2–40%. Both efficiency rates were significantly reduced by increases in water flow rate and/or salt concentration in the feed solution.

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74. Dissolution of hydrogen and the ratio of the dissolved hydrogen content to the produced hydrogen in electrolyzed water using SPE water electrolyzer

Electrochimica Acta, Volume 48, Issue 27, 30 November 2003, Pages 4013-4019
Yoshinori Tanaka, Sakae Uchinashi, Yasuhiro Saihara, Kenji Kikuchi, Takuji Okaya and Zempachi Ogumi

Concentration of dissolved hydrogen in electrolyzed water using a solid polymer electrolyte (SPE) water electrolyzer was investigated using a DH-meter. A ratio of the dissolved hydrogen content to an amount of hydrogen concentration calculated from charge passed during electrolysis was estimated. The ratio increased from 10 to 20% with a decrease in current density from 3.0 to 0.3 A dm−2. The effect of the linear velocity of water on the ratio of dissolved hydrogen was studied. The cross-sectional area of the water channel was changed to change the linear velocity of water. The ratio of dissolved hydrogen increased with increasing the velocity. Due to the fast mass transport by high velocity, the small hydrogen bubbles are fast transferred by the diffusion into the bulk water and dissolved. The population density of the small hydrogen bubbles is found to have an effect on the ratio of the dissolving hydrogen.

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75. Electrolyzed oxidizing water treatment for decontamination of raw salmon inoculated with Escherichia coli O157:H7 and Listeria monocytogenes Scott A and response surface modeling

Journal of Food Engineering, Volume 72, Issue 3, February 2006, Pages 234-241
Nil P. Ozer and Ali Demirci

Raw fish is prone to the risk of microbial outbreaks due to contamination by pathogenic microorganisms, such as Escherichia coli O157:H7 and Listeria monocytogenes. Therefore, it is essential to treat raw fish to inactivate pathogenic microorganisms. Electrolyzed Oxidizing Water (EO) is a novel antimicrobial agent containing acidic solution with a pH of 2.6, Oxidation Reduction Potential (ORP) of 1150 mV, and 70–90 ppm free chlorine, and alkaline solution with a pH of 11.4 and ORP of −795 mV. This study was undertaken to evaluate the efficacy of acidic EO water treatment and alkaline EO water treatment followed by acidic EO water treatment at various temperatures for the inactivation of E. coli O157:H7 and L. monocytogenes Scott A on the muscle and skin surfaces of inoculated salmon fillets. Inoculated salmon fillets were treated with acidic EO water at 22 and 35 °C and 90 ppm free-chlorine solution as control at 22 °C for 2, 4, 8, 16, 32, and 64 min. The acidic EO water treatments resulted in a reduction of L. monocytogenes Scott A population in the range of 0.40 log10 CFU/g (60%) at 22 °C to 1.12 log10 CFU/g (92.3%) at 35 °C. Treatment of inoculated salmon fillets with acidic EO water reduced E. coli O157:H7 populations by 0.49 log10 CFU/g (67%) at 22 °C and 1.07 log10 CFU/g (91.1%) at 35 °C. The maximum reduction with chlorine solution (control) was 1.46 log10 CFU/g (96.3%) for E. coli O157:H7 and 1.3 log10 CFU/g (95.3%) for L. monocytogenes Scott A at 64 min. A response surface model was developed

for alkaline treatment followed by acidic EO water treatment to predict treatment times in the range of 5–30 min and temperatures in the range of 22–35 °C for effective treatment with alkaline EO water followed by acidic water, alkaline and acidic water treatments. Response surface analysis demonstrated maximum log reductions of 1.33 log10 CFU/g (95.3%) for E. coli O157:H7 and 1.09 log10 CFU/g (91.9%) for L. monocytogenes Scott A. Data collected from the treatments was used to develop empirical models as a function of treatment times and temperature for prediction of population of E. coli O157:H7 and L. monocytogenes Scott A. Correlations (R2) of 0.52 and 0.77 were obtained between model predicted and experimental log10 reduction for E. coli O157:H7 and L. monocytogenes Scott A reductions, respectively. These results clearly indicated that EO water has a potential to be used for decontamination of raw fish.

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76. Application of electrolyzed oxidizing water to reduce Listeria monocytogenes on ready-to-eat meats

Meat Science, Volume 71, Issue 2, October 2005, Pages 327-333
K.A. Fabrizio and C.N. Cutter

Experiments were conducted to determine the effectiveness of acidic (EOA) or basic electrolyzed oxidizing (EOB) water, alone or in combination, on ready-to-eat (RTE) meats to reduce Listeria monocytogenes (LM). Frankfurters or ham surfaces were experimentally inoculated with LM and subjected to dipping or spraying treatments (25 or 4 °C for up to 30 min) with EOA, EOB, and other food grade compounds. LM was reduced the greatest when frankfurters were treated with EOA and dipped at 25 °C for 15 min. A combination spray application of EOB/EOA also resulted in a slight reduction of LM on frankfurters and ham. However, reductions greater than 1 log CFU/g were not observed for the duration of the study. Even with a prolonged contact time, treatments with EOA or EOB were not enough to meet regulatory requirements for control of LM on RTE meats. As such, additional studies to identify food grade antimicrobials to control the pathogen on RTE meats are warranted.

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77. Application of electrolyzed oxidizing water on the reduction of bacterial contamination for seafood

Food Control, In Press, Corrected Proof, Available online 8 September 2005,
Yu-Ru Huang, Hung-Sheng Hsieh, Shin-Yuan Lin, Shin-Jung Lin, Yen-Con Hung and Deng-Fwu Hwang

For reducing bacterial contamination, electrolyzed oxidizing water (EO water) has been used to reduce microbial population on seafood and platform of fish retailer. The specimens of tilapia were inoculated with Escherichia coli and Vibrio parahaemolyticus, and then soaked into EO water for up to 10 min. EO water achieved additional 0.7 log CFU/cm2 reduction than tap water on E. coli after 1 min treatment and additional treatment time did not achieved additional reduction. EO water treatment also reduced V. parahaemolyticus, by 1.5 log CFU/cm2 after 5 min treatment and achieved 2.6 log CFU/cm2 reduction after 10 min. The pathogenic bacteria were not detected in EO water after soaking treatment. In

addition, EO water could effectively disinfect the platform of fish retailer in traditional markets and fish markets.

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78. Effects of flow rate, temperature and salt concentration on chemical and physical properties of electrolyzed oxidizing water

Journal of Food Engineering, Volume 66, Issue 2, January 2005, Pages 171-176
Shun-Yao Hsu

This study adopted a three-factor-three-level factorial design to study the effects of water flow rate, salt concentration and water temperature on pH, oxidation–reduction potential (ORP), total residual chlorine, dissolved oxygen, electrical conductivity and salinity of electrolyzed oxidizing water (EOW). Results indicated that pH and dissolved oxygen concentration were not affected by these processing factors. Increasing water flow rate decreased total chlorine concentration and ORP of the EOW. Increasing salt concentration increased total chlorine concentration and electrical conductivity of the EOW. Water temperature had minor effect on total chlorine concentration. The variations can be well described by linear or quadratic polynomial models.

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79. Effects of storage conditions on chemical and physical properties of electrolyzed oxidizing water

Journal of Food Engineering, Volume 65, Issue 3, December 2004, Pages 465-471
Shun-Yao Hsu and Hsiao-Yuan Kao

Electrolyzed oxidizing waters (EOWs) were generated at different water flow rates, salt concentrations and water temperatures. The EOWs were stored in closed dark-brown glass bottles at room temperature for 21 days. Another duplicated set of the EOWs were stored for 12 days with four periodical openings of the screw caps. The effects of these treatments on pH, oxidation–reduction potential (ORP), electrical conductivity, total residual chlorine, dissolved oxygen (DO), sodium ion and chloride ion concentrations of the EOWs were investigated. Results indicated that pH, ORP, conductivity and chloride ion concentration did not change much under the storage conditions. Sodium ion concentration decreased 10–13% during storage. Total residual chlorine and DO decreased 24% and 21%, respectively, in the 21-day closed storage and decreased 81% and 47%, respectively, in the 12-day semi-open storage. This indicated that exposure to the atmosphere reduced more of these compounds than prolongation of the storage time.

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80. Effect of mild heat pre-treatment with alkaline electrolyzed water on the efficacy of acidic electrolyzed water against Escherichia coli O157:H7 and Salmonella on Lettuce

Food Microbiology, Volume 21, Issue 5, October 2004, Pages 559-566
Shigenobu Koseki, Kyoichiro Yoshida, Yoshinori Kamitani, Seiichiro Isobe and Kazuhiko Itoh

Cut lettuce dip-inoculated with Escherichia coli O157:H7 and Salmonella was treated with alkaline electrolyzed water (AlEW) at 20°C for 5 min, and subsequently washed with acidic electrolyzed water (AcEW) at 20°C for 5 min. Pre-treatment with AlEW resulted in an approximate 1.8 log10 cfu/g reduction of microbial populations, which was significantly (pless-than-or-equals, slant0.05) greater than microbial reductions resulting from other pre-treatment solutions, including distilled water and AcEW. Repeated AcEW treatment did not show a significant bacterial reduction. Mildly heated (50°C) sanitizers were compared with normal (20°C) or chilled (4°C) sanitizers for their bactericidal effect. Mildly heated AcEW and chlorinated water (200 ppm free available chlorine) with a treatment period of 1 or 5 min produced equal reductions of pathogenic bacteria of 3 log10 and 4 log10 cfu/g, respectively. The procedure of treating with mildly heated AlEW for 5 min, and subsequent washing with chilled (4°C) AcEW for period of 1 or 5 min resulted in 3–4 log10 cfu/g reductions of both the pathogenic bacterial counts on lettuce. Extending the mild heat pre-treatment time increased the bactericidal effect more than that observed from the subsequent washing time with chilled AcEW. The appearance of the mildly heated lettuce was not deteriorated after the treatment. In this study, we have illustrated the efficacious application of AlEW as a pre-wash agent, and the effective combined use of AlEW and AcEW.

Endoscopic Disinfection: Comparison Between Electrolyzed Acid Water and 2% Glutaraldehyde
Gastrointestinal Endoscopy, Volume 59, Issue 5, April 2004, Page P118
Giancarlo Spinzi, Alessandro Rampoldi, Luca Ferlin, Riccardo Terramocci, Giancarlo Butti and Giorgio Minoli

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81. Comparison of electrolyzed oxidizing water with other antimicrobial interventions to reduce pathogens on fresh pork

Meat Science, Volume 68, Issue 3, November 2004, Pages 463-468
K. A. Fabrizio and C. N. Cutter

To date, the effectiveness of electrolyzed oxidizing (EO) water against bacteria associated with fresh pork has not been determined. Using a hand-held, food-grade garden sprayer, distilled water (W), chlorinated water (CL; 25 ppm), 2% lactic acid (LA), acidic EO water (EOA), or "aged" acidic EO water (AEOA; stored at 4 °C for 24 h) was sprayed (15 s) onto pork bellies inoculated with feces containing Listeria monocytogenes (LM), Salmonella typhimurium (ST), and Campylobacter coli (CC). Remaining bacterial populations were determined immediately following treatment, after 2 days of aerobic storage, and again after 5 days of vacuum-packaged, refrigerated storage (day 7). While LA and EOA significantly reduced ($p<0.05$) populations of CC at days 0 and 7, there was no significant difference ($p>0.05$) between antimicrobial treatments when applied to pork inoculated with ST or LM. This study demonstrates that a 15-s spray with EOA has the ability to reduce CC associated with fresh pork surfaces. However, longer contact times may be necessary to reduce other microbial contaminants.

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82. Microbial reduction and storage quality of fresh-cut cilantro washed with acidic electrolyzed water and aqueous ozone

Food Research International, Volume 37, Issue 10, 2004, Pages 949-956
Hua Wang, Hao Feng and Yaguang Luo

Efficacy of decontamination treatments in reducing microbial populations on cilantro and in improving its storage quality was investigated. Fresh-cut cilantro samples were washed with one of the five treatments: tap water, acidic electrolyzed water (AEW), aqueous ozone, chlorinated water, and aqueous ozone followed by AEW (sequential wash). Treated cilantro was packaged in polyethylene bags prepared with films of selected oxygen transmission rate of 6200 mL/(d m2) and stored at 0 °C for 14 days. The total aerobic bacterial population, total enterobacteriaceae, electrolyte leakage and sensory qualities were examined every 4 days. Test results indicated that the sequential wash is effective in initial microbial count reduction. This treatment also maintained low microbial growth during storage. However, the higher electrolyte leakage may indicate cilantro tissue damage in this treatment. Using AEW alone also resulted in moderate control of aerobic bacterial growth during storage. Ozone treatment, on the other hand, achieved the highest overall quality of cilantro during storage and also maintained the typical cilantro aroma.