

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 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 ionized **water** and its health benefits. At his practice, they give away 300/400 gallons of Ionized **Water** daily to existing patients.

Now a professor of surgery at Albert Einstein College of Medicine and head of the Endoscopic Center of Beth Israel Hospital in New York, Dr Hiromi Shinya, runs private clinics in New York and Japan. He is the inventor of the modern colonoscope. **He concludes his book, “The Enzyme Factor” with this statement: “Kangen Water™ is alkaline rich **water** (pH 8-9), and is considered the very best drinking water because of its incomparable powers of hydration, detoxification, and anti-oxidation.” (Page 159)**

“Alkaline water produced by a water ionizer has become the most important advancement in health care since Sir Alexander Fleming's discovery of penicillin.”... Dr. William Kelly, College of Metabolic Medicine

“Drinking ionized water raises your cellular pH and fights off the free radicals which would otherwise damage the prostate as well as general health. Free radicals are like cellular "buzz saws" that rip through healthy tissue, destroying everything in their wake. Keeping free radicals under control is vital. Using a small device attached to your faucet, you can make ionized water at home. **“Larry Clapp, PhD, JD, author of “Prostate Health in 90 Days without Drugs or Surgery”**

"I have been measuring the levels of oxidation in bodily fluids for most of a decade. Many months of testing and research have led me to discover that drinking Ionized Alkaline water is the most effective tool for quickly and easily changing the ORP (oxidation reduction potential) I have ever encountered" from... **"Not All Water Is Equal" by Dr. Peggy Parker.** Dr. Parker also earned a post doctoral degree in Biological Medicine from the PBMN in Lustmuhle, Switzerland

I spent almost ten years researching the clinic use of alkaline and acidic ionized waters. During these clinic practices, lots of disease are very well under control and even cured amazingly after the patients drinking ionized alkaline water and using topically, ionized acidic water" by **Professor Yulian Wang, M.D., author of clinical research book "Ionized Water" and consultant to China Health Care Association.**

"Acidosis (acid build up) leads to serious problems with major organs such as the liver, heart or kidneys. Acidosis can result in diabetes, arthritis, osteoporosis, high blood pressure, most cancers, lupus and tuberculosis" ...by **Michael Lam, M.D., M.P.H., A.B.A.A.M. .**

"Disease Is Caused By a Deficiency of Oxygen, Water and Nutrients" by **Dr. Felicitas D.Tobias, M.D., Tobias Healing Institute in Chicago.** (They have four alkaline water ionizers!)

Dr. Ray Kurzweil and Dr. Terry Grossman, authors of "Fantastic Voyage: Live Long Enough to Live Forever" state that: "Consuming the right type of water is vital to detoxifying the body's acidic waste products and is one of the most powerful health treatments available. We recommend that you drink 8-10 glasses per day of this alkaline water. It is one of the simplest and most powerful things that you can do to combat a wide range of disease processes."

Dr. Gabriel Cousins, author of "Conscious Eating" says it simply: "Water ionization could be one of the most important health breakthroughs in our era."



Why do these experts drink Alkaline Water?

Dr Ray Kurzweil and Dr Terry Grossman, in their groundbreaking book "*Fantastic Voyage: Live Long Enough to Live Forever*" state that:

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teams drink alkaline water to improve their performance"



Ray Kurzweil is one of the world's leading inventors, thinkers, and futurists. Called "*the restless genius*" by the Wall Street Journal and "*the ultimate thinking machine*" by Forbes magazine, Kurzweil's ideas on the future have been touted by his many fans, who range from Bill Gates to Bill Clinton.

Time magazine writes:

"Kurzweil's eclectic career and propensity of combining science with practical—often humanitarian—applications have inspired comparisons with Thomas Edison."

Ray Kurzweil has been awarded 12 honorary doctorates, and honoured by 3 US Presidents, including Bill Clinton.



TERRY GROSSMAN, MD, is the founder and medical director of Frontier Medical Institute in Denver, Colorado. His longevity medical practice attracts patients, including many VIPs (such as coauthor Ray Kurzweil) from around the country and the world.

He is a member and board certified by the American Academy of Anti-Aging Medicine as well as the American Holistic Medical Association. His special field of interest is nutritional medicine (the treatment of illness with nutrients such as vitamins, minerals, anti-oxidants and natural hormones) and anti-aging medicine.

Dr. Grossman is licensed as an M.D., and an M.D.(H), a homeopathic medical doctor.

He is assistant professor of family practice at The University of Colorado School of Medicine.

"Consuming the right type of water is vital to detoxifying the body's acidic waste products and is one of the most powerful health treatments available." "We recommend that you drink 8-10 glasses per day of this alkaline water. It is one of the simplest and most powerful things that you can do to combat a wide range of disease processes. It is interesting to note that in Japan , professional sports teams drink alkaline water to improve their performance"

Dr Arthur M. Ecano, MD says:"*If the world has accepted antioxidants to slow down the aging process, it should readily agree to the uses of ionized alkaline water as an antiaging agent. Their roles are closely linked and intertwined such that a lasting antiaging program is incomplete without addressing both free radicals and organic acid wastes.*"

In 1996 Dr. Lynda Frassetto at the University of California, San Francisco, discovered that as we age, starting around age 45, we lose the alkaline buffer bicarbonates in our blood. By the age of 90, we lose 18% of bicarbonates in our blood. This loss was shown to be diet induced. This is from the published abstract: "***Our group has shown that contemporary net acid-producing diets do indeed characteristically produce a low-grade systemic metabolic acidosis in otherwise healthy adult subjects, and that the degree of acidosis increases with age, in relation to the normally occurring age-related decline in renal functional capacity.***"

Dr. Stephen Weiss explains that in the process of producing more stomach acid (hydrochloric acid), occasioned by the ingestion of ionized alkaline water, the body creates sodium bicarbonate (an alkaline buffer) and adds it to the bloodstream.

H₂O + CO₂ + NaCl = HCl + NaHCO₃ water + carbon dioxide + salt = hydrochloric acid + sodium bi-carbonate The net result is an increase in alkaline buffer. This does not happen if you ingest bicarbonates (baking soda) because the body converts these to water, carbon dioxide and sodium salt. The bicarbonates will not reach the bloodstream no matter how much you consume.

"If alkaline water is introduced directly into the bloodstream from the intestine, the acid buffer (carbonic acid, H₂CO₃) will interact with the alkaline water to bring down the blood pH and the acid buffer will become the alkaline buffer"

Ca(OH)₂ + 2(H₂CO₃) = Ca⁺⁺(HCO₃⁻)₂ + 2(H₂O) (calcium bicarbonate buffer in the blood is the net result)

An increase of bicarbonates in the bloodstream will prevent aging and the onset of adult degenerative diseases."

Clinical Studies Ionized Alkaline Water



This is a selection of Clinical Studies on the use of Alkaline Ionized (Reduced) Water.

Various Clinical Studies of Electrolyzed Reduced Water (Ionized Alkaline Water)

Anti-diabetic effects of electrolyzed reduced water in streptozotocin-induced and genetic diabetic mice.

Kim MJ, Kim HK.

Department of Obesity management, Graduate School of Obesity Science, Dongduk Women's University, 23-1 Wolkukdong, Seoul, 136-714, South Korea. mijakim@dongduk.ac.kr

Oxidative stress is produced under diabetic conditions and is likely involved in progression of pancreatic beta-cell dysfunction found in diabetes. Both an increase in reactive oxygen free radical species (ROS) and a decrease in the antioxidant defense mechanism lead to the increase in oxidative stress in diabetes. Electrolyzed reduced water (ERW) with ROS scavenging ability may have a potential effect on diabetic animals, a model for high oxidative stress. Therefore, the present study examined the possible anti-diabetic effect of ERW in two different diabetic animal models. The genetically diabetic mouse strain C57BL/6J-db/db (db/db) and streptozotocin (STZ)-induced diabetic mouse were used as insulin deficient type 1 and insulin resistant type 2 animal model, respectively. ERW, provided as a drinking water, significantly reduced the blood glucose concentration and improved glucose tolerance in both animal models. However, ERW fail to affect blood insulin levels in STZ-diabetic mice whereas blood insulin level was markedly increased in genetically diabetic db/db mice. This improved blood glucose control could result from enhanced insulin sensitivity, as well as increased insulin release. The present data suggest that ERW may function as an orally effective anti-diabetic agent and merit further studies on its precise mechanism.

PMID: 16945392 [PubMed - indexed for MEDLINE]
Life Sci. 2006 Nov 10;79(24):2288-92. Epub 2006 Aug 2

Preservative effect of electrolyzed reduced water on pancreatic beta-cell mass in diabetic db/db mice.

Kim MJ, Jung KH, Uhm YK, Leem KH, Kim HK.

Department of Obesity Management, Graduate School of Obesity Science, Dongduk Women's University, Seoul, South Korea. mijakim@dongduck.ac.jp

Oxidative stress is produced under diabetic conditions and involved in progression of pancreatic beta-cell dysfunction. Both an increase in reactive oxygen free radical species (ROS) and a decrease in the antioxidant defense mechanism lead to the increase in oxidative stress in diabetes. Electrolyzed reduced water (ERW) with ROS scavenging ability may have a potential effect on diabetic animals, a model for high oxidative stress. Therefore, the present study examined the possible anti-diabetic effect of ERW in genetically diabetic mouse strain C57BL/6J-db/db (db/db). ERW with ROS scavenging ability reduced the blood glucose concentration, increased blood insulin level, improved glucose tolerance and preserved beta-cell mass in db/db mice. The present data suggest that ERW may protect beta-cell damage and would be useful for antidiabetic agent.

PMID: 17268057 [PubMed - indexed for MEDLINE]
Biol Pharm Bull. 2007 Feb;30(2):234-6

Electrolyzed-reduced water protects against oxidative damage to DNA, RNA, and protein.

Lee MY, Kim YK, Ryoo KK, Lee YB, Park EJ.

Department of Genetic Engineering, Soonchunhyang University, Asan, Chungnam 336-600, Korea. miyoung@sch.ac.kr

The generation of reactive oxygen species is thought to cause extensive oxidative damage to various biomolecules such as DNA, RNA, and protein. In this study, the preventive, suppressive, and protective effects of in vitro supplementation with electrolyzed-reduced water on H₂O₂-induced DNA damage in human lymphocytes were examined using a comet assay. Pretreatment, cotreatment, and posttreatment with electrolyzed-reduced water enhanced human lymphocyte resistance to the DNA strand breaks induced by H₂O₂ in vitro. Moreover, electrolyzed-reduced water was much more effective than diethylpyrocarbonate-treated water in preventing total RNA degradation at 4 and 25 degrees C. In addition, electrolyzed-reduced water completely prevented the oxidative cleavage of horseradish peroxidase, as determined using sodium dodecyl sulfate-polyacrylamide gels. Enhancement of the antioxidant activity of ascorbic acid dissolved in electrolyzed-reduced water was about threefold that of ascorbic acid dissolved in nonelectrolyzed deionized water, as measured by a xanthine-xanthine oxidase superoxide scavenging assay system, suggesting an inhibitory effect of electrolyzed-reduced water on the oxidation of ascorbic acid.

PMID: 17159237 [PubMed - indexed for MEDLINE]
Appl Biochem Biotechnol. 2006 Nov;135(2):133-44

The mechanism of the enhanced antioxidant effects against superoxide anion radicals of reduced water produced by electrolysis.

Hanaoka K, Sun D, Lawrence R, Kamitani Y, Fernandes G.

Bio-REDOX Laboratory Inc. 1187-4, Oaza-Ueda, Ueda-shi, Nagano-ken 386-0001, Japan. hanak@rapid.ocn.ne.jp

We reported that reduced water produced by electrolysis enhanced the antioxidant effects of proton donors such as ascorbic

acid (AsA) in a previous paper. We also demonstrated that reduced water produced by electrolysis of 2 mM NaCl solutions did not show antioxidant effects by itself. We reasoned that the enhancement of antioxidant effects may be due to the increase of the ionic product of water as solvent. The ionic product of water (pK_w) was estimated by measurements of pH and by a neutralization titration method. As an indicator of oxidative damage, Reactive Oxygen Species- (ROS) mediated DNA strand breaks were measured by the conversion of supercoiled phiX-174 RF I double-strand DNA to open and linear forms. Reduced water had a tendency to suppress single-strand breakage of DNA induced by reactive oxygen species produced by H₂O₂/Cu (II) and HQ/Cu (II) systems. The enhancement of superoxide anion radical dismutation activity can be explained by changes in the ionic product of water in the reduced water.

PMID: 14871602 [PubMed - indexed for MEDLINE]
Biophys Chem. 2004 Jan 1;107(1):71-82

Electrolyzed-reduced water reduced hemodialysis-induced erythrocyte impairment in end-stage renal disease patients.

Huang KC, Yang CC, Hsu SP, Lee KT, Liu HW, Morisawa S, Otsubo K, Chien CT.

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

Chronic hemodialysis (HD) patients increase erythrocyte susceptibility to hemolysis and impair cell survival. We explored whether electrolyte-reduced water (ERW) could palliate HD-evoked erythrocyte impairment and anemia. Forty-three patients undergoing chronic HD were enrolled and received ERW administration for 6 month. We evaluated oxidative stress in blood and plasma, erythrocyte methemoglobin (metHb)/ferricyanide reductase activity, plasma metHb, and proinflammatory cytokines in the chronic HD patients without treatment (n=15) or with vitamin C (VC)- (n=15), vitamin E (VE)-coated dialyzer (n=15), or ERW treatment (n=15) during an HD course. The patients showed marked increases (15-fold) in blood reactive oxygen species, mostly H₂O₂, after HD without any treatment. HD resulted in decreased plasma VC, total antioxidant status, and erythrocyte methHb/ferricyanide reductase activity and increased erythrocyte levels of phosphatidylcholine hydroperoxide (PCOOH) and plasma metHb. Antioxidants treatment significantly palliated single HD course-induced oxidative stress, plasma and RBC PCOOH, and plasma metHb levels, and preserved erythrocyte metHb /ferricyanide reductase activity in an order VC>ERW>VE-coated dialyzer. However, ERW had no side effects of oxalate accumulation easily induced by VC. Six-month ERW treatment increased hematocrit and attenuated proinflammatory cytokines profile in the HD patients. In conclusion, ERW treatment administration is effective in palliating HD-evoked oxidative stress, as indicated by lipid peroxidation, hemolysis, and overexpression of proinflammatory cytokines in HD patients.

PMID: 16760903 [PubMed - indexed for MEDLINE]
Kidney Int. 2006 Jul;70(2):391-8. Epub 2006 Jun 7

Influences of alkaline ionized water on milk yield, body weight of offspring and perinatal dam in rats.

J Toxicol Sci. 1998 Dec;23(5):365-71. Watanabe T , Pan I , Fukuda Y , Murasugi E , Kamata H , Uwatoko K .

Department of Veterinary Physiological Chemistry, College of Bioresource Sciences, Nihon University, Kanagawa, Japan.

The authors previously reported that male offspring of mothers rats given alkaline ionized water (AKW) showed a significantly higher body weight by day 14 after birth than did offspring of mother rats given tap water (TPW); furthermore, marked myocardial necrosis and fibrosis were observed particularly in the former male offspring at the age of 15 weeks. In the

present experiment we looked for differences in bioparameters, namely the milk yield of mothers and suckled milk volume of the offspring, between the AKW- and the TPW-treated groups in order to reveal the factors which cause the unusual body weight gain in the offspring. Even though we were able to repeat our previous observation (the body weight of the male offspring of the AKW group increased significantly more by day 14 and 20 after birth and of the female by day 20 after birth than did that of the TPW group ($p < 0.05$), no significant difference was noted in any of the bioparameters, including those related to milk production and consumption. It is thus suspected that the water-hydrated cation, which was transferred either to the fetus through the placenta or to the offspring through the milk, might be the cause of the unusual body weight increase. Since calcium plays an important role in skeletal formation, it is tentatively concluded that the higher calcium concentration of AKW enriched the mother, serum calcium which was transferred to the fetus through the placenta and to the offspring through the milk.

PMID: 9922938 [PubMed - indexed for MEDLINE]

Histopathological influence of alkaline ionized water on myocardial muscle of mother rats.

J Toxicol Sci. 1998 Dec;23(5):411-7. Watanabe T , Shirai W , Pan I , Fukuda Y , Murasugi E , Sato T , Kamata H , Uwatoko K .

Department of Veterinary Physiological Chemistry, College of Bioresource Sciences, Nihon University, Kanagawa, Japan.

We have reported that a marked necrosis and subsequent fibrosis of myocardium occurred among male rats 15 weeks old given alkaline ionized water (AKW) during gestation and suckling periods, and after weaning. In this study, it was examined whether similar lesions would occur in mother rats which were given AKW from day zero of gestation to day 20 of lactation. The myocardial lesion in the mother rats given AKW showed cell infiltration, vacuolation and fibrosis in the papillary muscle of the left ventricle, as were observed in male rats of 15 weeks old. Myocardial degeneration may cause a leakage of potassium into the blood that results in a higher concentration of potassium in the blood in the test group than in that of the control group given tap water.

PMID: 9922944 [PubMed - indexed for MEDLINE]

[Editors note: This and the following study were negative, suggesting that caution should be used on the dosage. Japanese doctors recommend drinking Alkaline Water with pH between 8 and 9, more is not necessarily better. All other clinical studies have been positive]

Degradation of myocardiac myosin and creatine kinase in rats given alkaline ionized water.

J Vet Med Sci. 1998 Feb;60(2):245-50. Watanabe T , Kishikawa Y .

Department of Veterinary Physiological Chemistry, College of Bioresource Sciences, Nihon University, Kanagawa, Japan.

Recently, the authors have shown that marked necrosis and fibrosis of myocardium were observed in rats given alkaline ionized water (AKW). To clarify the cause of myocardial lesions, the activities of myosin ATPase, actomyosin ATPase and creatine kinase (CK) in myocardium of rats given AKW at 15 weeks-old were compared with those in myocardium of rats given tap water (TPW). Furthermore, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) of myocardiac myosin and isoelectric focusing (IEF) of myocardiac CK were performed which revealed a distinct difference between AKW and TPW groups. The activities of myosin ATPase and actomyosin ATPase in the AKW group were higher than those in the

TPW group, and these elevated activities were caused by the degradation of myosin in the AKW group judging from the SDS-PAGE pattern of myosin. On the other hand, the activity of CK in the AKW group was lower than that in the TPW group, and the IEF pattern of CK showed leakage of myocardial CK. These results indicate that increases in actomyosin ATPase activity and myosin ATPase activity, plus the decrease in CK activity caused the disorder of coupled reaction in male rats given AKW at 15 weeks-old. It is concluded that this disorder of coupled reaction may cause marked myocardial necrosis and fibrosis in rats given AKW.

PMID: 9524951 [PubMed - indexed for MEDLINE]

Influence of alkaline ionized water on rat erythrocyte hexokinase activity and myocardium.

J Toxicol Sci. 1997 May;22(2):141-52. Watanabe T , Kishikawa Y , Shirai W .

Department of Veterinary Physiological Chemistry, College of Bioresource Science, Nihon University, Kanagawa, Japan.

Alkaline ionized water (AKW) produced by the electrolysis of tap water (TPW) was given to pregnant rats throughout gestation. AKW was subsequently given to infants as a test group until 15 weeks old to determine changes in body and organ weights, erythrocyte hexokinase (HK) activity and histological preparations of myocardial muscle. The results were compared with those for rats given TPW. Body weight of male and female rats given AKWA at 3 to 11 weeks of age after birth significantly increased beyond control group values. Organ weights of offspring at 15 weeks-old showed no statistical difference for either group. HK activity, the rate-determining enzyme in erythrocyte glycolysis, significantly increased in males given AKW at 15 weeks-old. This suggests that AKW intake causes elevation of metabolic activity. Hyperkalemia was observed in males and females given AKW at 15 weeks-old. Especially in males, pathological changes of necrosis in myocardial muscle were observed.

PMID: 9198011 [PubMed - indexed for MEDLINE]

Anticancer Effect of alkaline ionized water, (does not reproduce well, view as PDF) <http://www.adlux.fi/public/pdf/anticancereffect.pdf>

1. The efficacy of function water (electrolyzed strong acid solution) on open heart surgery; postoperative mediastinitis due to methicillin-resistant Staphylococcus aureus

Kyobu Geka. 2004 Nov;57(12):1110-2. [Article in Japanese]

Ichihara T , Fujii G , Eda T , Sasaki M , Ueda Y .

Department of Cardiovascular Surgery, Tosei General Hospital, Seto, Japan.

Methicillin-resistant Staphylococcus aureus (MRSA) infection after cardiac surgery has recently increased. We compared the anti-inflammatory effect of an electrolyzed strong acid solution and a warm saline solution in patients with open heart surgery. These solutions were used for mediastinal irrigation before closing the sternum. Group A patients were irrigated by a warm saline solution, and group B patients were irrigated by an electrolyzed strong acid solution, administration of this 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]

Effect of alkaline ionized water on reproduction in gestational and lactational rats.

J Toxicol Sci. 1995 May;20(2):135-42. Watanabe T .

Department of Veterinary Physiological Chemistry, College of Agriculture and Veterinary Medicine, Nihon University, Kanagawa, Japan.

Alkaline ionized water (AKW) produced by electrolysis was given to gestational and lactational rats, and its effect on dams, growth of fetuses and offsprings were investigated. The results showed that the intake of food and water in dams increased significantly when AKW was given from the latter half of the gestation period and from the former half of the lactation period. Body weight of the offsprings in the test group, both males and females, increased significantly from the latter half of the lactation period. During the lactation period and after weaning, the offsprings in the test group showed significantly hastened appearance of abdominal hair, eruption of upper incisors, opening of eyelids and other postnatal morphological developments both in males and females, as well as earlier separation of auricle and descent of testes in males compared with the control was noted. As mentioned above, it was suggested from the observations conducted that the AKW has substantial biological effects on postnatal growth, since intake of food and water and body weight of the offsprings increased and postnatal morphological development was also accelerated.

PMID: 7473891 [PubMed - indexed for MEDLINE]

Impact of extra waters on immunosystem in mice

Wei Sheng Yan Jiu. 2004 Jul;33(4):422-5. [Article in Chinese]

Li Y , Han C , Li Y , Li Y , Zhao X , Zhong K , Chen T , Zhang M , Fan F , Tao Y , Ji R .

Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing 100021, China.

OBJECTIVE: To study impact of extra waters on immunosystem in mice-alkaline ionized water, mineral ecology water, activated water, and pure water. METHODS: According to Function Assessment and Experiment for Function Food, 1996, the ratio of spleen and body weight, the ratio of thymus and body weight, the delayed type hypersensitivity (DTH), the phagocytosing functions by cock RBC, the plaque forming cell (PFC) and HC50 testing were assessment with 120 male Balb/c mice of 17.8 - 23.3 g (group I), the mice were divided into four group, and drank daily the four kinds of waters respectively until 50 days. The lymph cell transformation by ConA and NK cell activity were assessment with other 120 male Balb/c mice of 17.8 - 23.3 g (group II), the mice were divided into four group and drank daily the four kinds of waters respectively until 50 days. The phagocytosing functions by carbon powder were assessment with other 120 female Balb/c mice of 16.7 - 22.0 g (group III) were divided into four group and drank daily the four kinds of waters respectively until 50 days. The data were statisticed by Stata soft. RESULTS: Other three waters compared with the pure water: (1) Alkaline ionized water and activated water can alleviate the body weight increase of male Balb/c mouse ($P < 0.01$ & $P < 0.05$), but alkaline ionized water, mineral ecology water, activated water don't impact on the female Balb/c mouse body weight ($P > 0.05$). (2) Activated water can remarkably increase the ratio of thymus and body weight ($P < 0.05$), and increase the phagocytosing ability by cock RBC ($P < 0.01$), and increase the NK cell activity ($P < 0.01$). (3) The three extra waters don't impact on other items for the Balb/c mouse. CONCLUSION: The study must be continued to impact on immunosystem in mice for extra waters.

PMID: 15461264 [PubMed - in process]

Selective stimulation of the growth of anaerobic microflora in the human intestinal tract by electrolyzed reducing water.

Med Hypotheses. 2005;64(3):543-6. Vorobjeva NV .

Department of Physiology of Microorganisms, Biology Faculty, Lomonosov Moscow State University, 119992 Moscow, Russia. nvvorobjeva@mail.ru 96-99% of the "friendly" or residential microflora of intestinal tract of humans consists of strict anaerobes and only 1-4% of aerobes. Many diseases of the intestine are due to a disturbance in the balance of the microorganisms inhabiting the gut. The treatment of such diseases involves the restoration of the quantity and/or balance of residential microflora in the intestinal tract. It is known that aerobes and anaerobes grow at different oxidation-reduction potentials (ORP). The former require positive E(h) values up to +400 mV. Anaerobes do not grow unless the E(h) value is negative between -300 and -400 mV. In this work, it is suggested that prerequisite for the recovery and maintenance of obligatory anaerobic microflora in the intestinal tract is a negative ORP value of the intestinal milieu. Electrolyzed reducing water with E(h) values between 0 and -300 mV produced in electrolysis devices possesses this property. Drinking such water favours the growth of residential microflora in the gut. A sufficient array of data confirms this idea. However, most researchers explain the mechanism of its action by an antioxidant properties destined to detox the oxidants in the gut and other host tissues. Evidence is presented in favour of the hypothesis that the primary target for electrolyzed reducing water is the residential microflora in the gut.

PMID: 15617863 [PubMed - indexed for MEDLINE]

Water desirable for health in terms of ORP (oxidation-reduction potential) to pH relationship

- Review
PMID: 16180690 [PubMed - indexed for MEDLINE] Shokuhin Eiseigaku Zasshi. 2005 Aug;46(4):J228-33. [Article in Japanese]

Okouchi S.

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Publication Types:

Review
PMID: 2829704 [PubMed - indexed for MEDLINE]

Influences of alkaline ionized water on milk electrolyte concentrations in maternal rats.

J Toxicol Sci. 2000 Dec;25(5):417-22. Watanabe T , Kamata H , Fukuda Y , Murasugi E , Sato T , Uwatoko K , Pan IJ .

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We previously reported that body weight on day 14 after birth in male offspring of rats given alkaline ionized water (AKW) was significantly heavier than that in offspring of rats given tap water (TPW), but no significant difference was noted in milk yield and in suckled milk volume between the two groups. Additionally, the offspring in the AKW group and TPW group were given AKW and TPW, respectively, at weaning, and unexpectedly, the necrotic foci in the cardiac muscle were observed at the 15-week-old age in the AKW group, but not in the TPW group. The present study was designed to clarify the factors which are involved in that unusual increase of body weight and occurrence of cardiac necrosis. Eight dams in each group were given AKW or TPW (control) from day 0 of gestation to day 14 of lactation. The milk samples were collected on day 14 of lactation and analyzed for concentrations of calcium (Ca), sodium (Na), potassium (K), magnesium (Mg) and chloride (Cl). The AKW and TPW were also analyzed. Ca, Na and K levels in milk were significantly higher in the AKW group compared to the TPW group. No significant difference was noted in the Mg and Cl levels between the two groups. These data suggested that the Ca cation of AKW enriched the Ca concentration of the milk and accelerated the postnatal growth of the offspring of rats given AKW.

PMID: 11201172 [PubMed - indexed for MEDLINE]

Electrolyzed-reduced water scavenges active oxygen species and protects DNA from oxidative damage.

Biochem Biophys Res Commun. 1997 May 8;234(1):269-74.

Shirahata S , Kabayama S , Nakano M , Miura T , Kusumoto K , Gotoh M , Hayashi H , Otsubo K , Morisawa S , Katakura Y .

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Active oxygen species or free radicals are considered to cause extensive oxidative damage to biological macromolecules, which brings about a variety of diseases as well as aging. The ideal scavenger for active oxygen should be 'active hydrogen'. 'Active hydrogen' can be produced in reduced water near the cathode during electrolysis of water. Reduced water exhibits high pH, low dissolved oxygen (DO), extremely high dissolved molecular hydrogen (DH), and extremely negative redox potential (RP) values. Strongly electrolyzed-reduced water, as well as ascorbic acid, (+)-catechin and tannic acid, completely scavenged O₂⁻ produced by the hypoxanthine-xanthine oxidase (HX-XOD) system in sodium phosphate buffer (pH 7.0). The superoxide dismutase (SOD)-like activity of reduced water is stable at 4 degrees C for over a month and was not lost even after neutralization, repeated freezing and melting, deflation with sonication, vigorous mixing, boiling, repeated filtration, or closed autoclaving, but was lost by opened autoclaving or by closed autoclaving in the presence of tungsten trioxide which efficiently adsorbs active atomic hydrogen. Water bubbled with hydrogen gas exhibited low DO, extremely high DH and extremely low RP values, as does reduced water, but it has no SOD-like activity. These results suggest that the SOD-like activity of reduced water is not due to the dissolved molecular hydrogen but due to the dissolved atomic hydrogen (active hydrogen). Although SOD accumulated H₂O₂ when added to the HX-XOD system, reduced water decreased the amount of H₂O₂ produced by XOD. Reduced water, as well as catalase and ascorbic acid, could directly scavenge H₂O₂. Reduced water suppresses single-strand breakage of DNA by active oxygen species produced by the Cu(II)-catalyzed oxidation of ascorbic acid in a dose-dependent manner, suggesting that reduced water can scavenge not only O₂⁻ and H₂O₂, but also 1O₂ and .OH.

PMID: 9169001 [PubMed - indexed for MEDLINE]

The mechanism of the enhanced antioxidant effects against superoxide anion radicals of reduced water produced by electrolysis.

Biophys Chem. 2004 Jan 1;107(1):71-82.

Hanaoka K , Sun D , Lawrence R , Kamitani Y , Fernandes G .

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We reported that reduced water produced by electrolysis enhanced the antioxidant effects of proton donors such as ascorbic acid (AsA) in a previous paper. We also demonstrated that reduced water produced by electrolysis of 2 mM NaCl solutions did not show antioxidant effects by itself. We reasoned that the enhancement of antioxidant effects may be due to the increase of the ionic product of water as solvent. The ionic product of water (pK_w) was estimated by measurements of pH and by a neutralization titration method. As an indicator of oxidative damage, Reactive Oxygen Species- (ROS) mediated DNA strand breaks were measured by the conversion of supercoiled phiX-174 RF I double-strand DNA to open and linear forms. Reduced water had a tendency to suppress single-strand breakage of DNA induced by reactive oxygen species produced by H₂O₂/Cu (II) and HQ/Cu (II) systems. The enhancement of superoxide anion radical dismutation activity can be explained by changes in the ionic product of water in the reduced water.

PMID: 14871602 [PubMed - indexed for MEDLINE]

Protective mechanism of reduced water against alloxan-induced pancreatic beta-cell damage: Scavenging effect against reactive oxygen species

Authors: Li Y.1; Nishimura T.1; Teruya K.1; Maki T.1; Komatsu T.1; Hamasaki T.1; Kashiwagi T.1; Kabayama S.2; Shim S-Y.1; Katakura Y.1; Osada K.1; Kawahara T.1; Otsubo K.2; Morisawa S.2; Ishii Y.3; Gadek Z.4; Shirahata S.5

Source: Cytotechnology, Volume 40, Numbers 1-3, 2002, pp. 139-149(11)

Publisher: Springer

Abstract:

Reactive oxygen species (ROS) cause irreversible damage to biological macromolecules, resulting in many diseases. Reduced water (RW) such as hydrogen-rich electrolyzed reduced water and natural reduced waters like Hita Tenryosui water in Japan and Nordenau water in Germany that are known to improve various diseases, could protect a hamster pancreatic beta cell line, HIT-T15 from alloxan-induced cell damage. Alloxan, a diabetogenic compound, is used to induce type 1 diabetes mellitus in animals. Its diabetogenic effect is exerted via the production of ROS. Alloxan-treated HIT-T15 cells exhibited lowered viability, increased intracellular ROS levels, elevated cytosolic free Ca²⁺ concentration, DNA fragmentation, decreased intracellular ATP levels and lowering of glucose-stimulated release of insulin. RW completely prevented the generation of alloxan-induced ROS, increase of cytosolic Ca²⁺ concentration, decrease of intracellular ATP level, and lowering of glucose-stimulated insulin release, and strongly blocked DNA fragmentation, partially suppressing the lowering of viability of alloxan-treated cells. Intracellular ATP levels and glucose-stimulated insulin secretion were increased by RW to 2–3.5 times and 2–4 times, respectively, suggesting that RW enhances the glucose-sensitivity and glucose response of beta-cells. The protective activity of RW was stable at 4 °C for over a month, but was lost by autoclaving. These results suggest that RW protects pancreatic beta-cells from alloxan-induced cell damage by preventing alloxan-derived ROS generation. RW may be useful in preventing alloxan-induced type 1-diabetes mellitus.

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Electrolyzed hydrogen-saturated water for drinking use elicits an antioxidative effect: a feeding test with rats.

Biosci Biotechnol Biochem. 2005 Oct;69(10):1985-7

Yanagihara T, Arai K, Miyamae K, Sato B, Shudo T, Yamada M, Aoyama M.

MiZ Co., Ltd., Fujisawa-shi, Kanagawa, Japan.

A new type of electrolyzed hydrogen-saturated (EHS) water was produced using a water-electrolyzing device equipped with a special cation exchanger. Use of the EHS water for drinking in a feeding test with rats elicited an antioxidative effect. After intraperitoneal injection of 2,2-azobis-amidinopropane dihydrochloride, urinary secretion of 8-hydroxydeoxyguanosine and hepatic formation of peroxidized lipid were significantly lessened in rats which had received the EHS water for one week. These results suggest the possibility that this drinking water shows an effect in reduction of oxidative stress in the body.

PMID: 16244454 [PubMed - in process]

[Editors note: following two studies are not about ionized water, but about effects of increasing alkaline minerals JK]

Effects of supplementing of calcium, iron and zinc on women's health during pregnancy

Zhonghua Yu Fang Yi Xue Za Zhi. 2001 Nov;35(6):365-9. [Article in Chinese]

An H, Yin S, Xu Q.

Department of Maternal and Child Nutrition, Institute of Nutrition and Food Hygiene, Chinese Academy of Preventive Medicine, Beijing 100050, China.

OBJECTIVES: To determine the effects of supplementing biscuits fortified with calcium (Ca) and vitamin D (VD), iron (Fe), vitamin C (VC) and zinc (Zn) to pregnant women from the 5th month of gestation until delivery on their health, and to explore a way to improve their Ca, Fe and Zn nutritional status during pregnancy. **METHODS:** A total of 313 healthy and primary pregnant women were enrolled and divided into five study groups based on their order visiting the hospitals for prenatal care. Each woman of the study groups was given three pieces of biscuit fortified with VD, Ca and VD, Ca, Zn and VD (Ca + Zn + VD), Ca, Fe, VC and VD (Ca + Fe + VD), Ca, Fe, VC, Zn and VD (Ca + Fe + Zn + VD), respectively, from the 15th month of gestation until delivery (24 weeks in total) daily. The fortified levels were 10 micrograms VD, 400 mg Ca from carbonate calcium, 10 mg Zn from lactate zinc, 10 mg Fe from ferrous lactate, and 50 mg VC, respectively. A parturient woman was selected from the same hospital as control after one trial subject for each study groups selected. **RESULTS:** The daily dietary

intakes of Ca, Zn and Fe in pregnant women were only 47.7%, 54.7% and 86.7% of the Recommended Dietary Allowances for Chinese. Incidence of anemia for mid-term pregnant women was 35.2%, and Fe-supplementation could significantly improved their hemoglobin level ($P < 0.05$). Prevalence of anemia in the groups of Ca + Fe + Zn + VD and Ca + Fe + VD was 35.3% and 40.7%, respectively, before Fe supplementation and reduced to zero and 4.0%, respectively, after Fe supplementation. Whereas, prevalence of anemia in the other groups without Fe supplementation still kept in a relatively high level. In the groups supplemented with Ca, their plasma Ca level increased, especially with the best results in Ca + VD group. Plasma level of Zn declined with length of gestation, which could be improved by Zn supplementation. Serum level of alkaline phosphatase activity increased a little bit with length of gestation. There was no significant difference in radial and ulnar bone mineral density (BMD) between trial groups and controls two months after delivery. Maternal radial and ulnar BMD correlated significantly with their dietary Ca intakes in Ca + VD group. CONCLUSION: The best way to improve maternal nutritional status is supplementation of Ca + Fe + Zn + VitD, based on the Recommended Dietary Allowances for Chinese.

PMID: 11840760 [PubMed - indexed for MEDLINE]

Supplementation with alkaline minerals reduces symptoms in patients with chronic low back pain.

1: J Trace Elem Med Biol. 2001;15(2-3):179-83.

Vormann J, Worlitschek M, Goedecke T, Silver B.

Institut für Prävention und Ernährung, Ismaning, Germany. vormann@ipev.de

The cause of low back pain is heterogeneous, it has been hypothesised that a latent chronic acidosis might contribute to these symptoms. It was tested whether a supplementation with alkaline minerals would influence symptoms in patients with low back pain symptoms. In an open prospective study 82 patients with chronic low back pain received daily 30 g of a lactose based alkaline multimineral supplement (Basica) over a period of 4 weeks in addition to their usual medication. Pain symptoms were quantified with the "Arhus low back pain rating scale" (ARS). Mean ARS dropped highly significant by 49% from 41 to 21 points after 4 weeks supplementation. In 76 out of 82 patients a reduction in ARS was achieved by the supplementation. Total blood buffering capacity was significantly increased from 77.69 ± 6.79 to 80.16 ± 5.24 mmol/L (mean \pm SEM, $n = 82$, $p < 0.001$) and also blood pH rose from 7.456 ± 0.007 to 7.470 ± 0.007 (mean \pm SEM, $n = 75$, $p < 0.05$). Only intracellular magnesium increased by 11% while other intracellular minerals were not significantly changed in sublingual tissue as measured with the EXA-test. Plasma concentrations of potassium, calcium, iron, copper, and zinc were within the normal range and not significantly influenced by the supplementation. Plasma magnesium was slightly reduced after the supplementation (-3% , $p < 0.05$). The results show that a disturbed acid-base balance may contribute to the symptoms of low back pain. The simple and safe addition of an alkaline multimineral preparate was able to reduce the pain symptoms in these patients with chronic low back pain.

Publication Types:

* Clinical Trial

PMID: 11787986 [PubMed - indexed for MEDLINE]

A. Clinical Reports on the Effects of Ionized Water

1. Physiological effects of alkaline ionized water: Effects on metabolites

- produced by intestinal fermentation**
- 2. Clinical evaluation of alkaline ionized water for abdominal complaints: Placebo controlled double blind tests**
 - 3. Effect of Electrolytic Water (Ionized Water) Intake on Lifespan of Autoimmune Disease Prone Mice**
 - 4. Reduced Water for Prevention of Diseases**
 - 5. Clinical Improvements Obtained From The Intake Of Reduced Water**
 - 6. Effects of alkaline ionized water on formation & maintenance of osseous tissues**

B. Korean TV Reported scientific Results on the effects of Ionized Water

(Broadcast in 2004)

- 1. Anti-cancer Effects**
- 2. Anti-Oxidization Effects**
- 3. Increase of Immune Function**
- 4. Diabetes**
- 5. Protection of DNA in tissues**

A. Clinical Reports on the Effects of Ionized Water

1. Physiological effects of alkaline ionized water: Effects on metabolites produced by intestinal fermentation

Takashi Hayakawa, Chicko Tushiya, Hisanori Onoda, Hisayo Ohkouchi, Haruto Tsuge (Gifu University, Faculty of Engineering, Dept. of Food Science)

"We have found that long-term ingestion of alkaline ionized water (AIW) reduces cecal fermentation in rats that were given highly fermentable commercial diet (MF: Oriental Yeast Co., Ltd.). In this experiment, rats were fed MF and test water (tap water, AIW with pH at 9 and 10) for about 3 months. Feces were collected on the 57th day, and the rats were dissected on the 88th day. The amount of ammonium in fresh feces and cecal contents as well as fecal free-glucose tended to drop down for the AIW group. In most cases, the amount of free-amino

acids in cecal contents did not differ significantly except for cysteine (decreased in AIW with pH at 10) and isoleucine (increased in AIW with pH at 10).

Purpose of tests

Alkaline ionized water electrolyzers have been approved for manufacturing in 1965 by the Ministry of Health and Welfare as medical equipment to produce medical substances.

Alkaline ionized water (AIW) produced by this equipment is known to be effective against gastrointestinal fermentation, chronic diarrhea, indigestion and hyperchylia as well as for controlling gastric acid.

1. This is mainly based on efficacy of the official calcium hydroxide.
2. By giving AIW to rats for a comparatively long time under the condition of extremely high level of intestinal fermentation, we have demonstrated that AIW intake is effective for inhibition of intestinal fermentation when its level is high based on some test results where AIW worked against cecal hypertrophy and for reduction in the amount of short-chain fatty acid that is the main product of fermentation.
3. We have reported that this is caused by the synergy between calcium level generally contained in AIW (about 50ppm) and the value of pH, and that frequency of detecting some anaerobic bacteria tends to be higher in alkaline ionized water groups than the other, although the bacteria count in the intestine does not have significant difference. Based on these results, we made a judgment that effect of taking AIW supports part of inhibition mechanism against abnormal intestinal fermentation, which is one of the claims of efficacy that have been attributed to alkaline ionized water electrolyzers.
4. On the other hand, under the dietary condition of low intestinal fermentation, AIW uptake does not seem to inhibit fermentation that leads us to believe that effect of AIW uptake is characteristic of hyper-fermentation state. Metabolites produced by intestinal fermentation include indole and skatole in addition to organic acids such as short-chain fatty acid and lactic acid as well as toxic metabolites such as ammonium, phenol and p-cresol. We do not know how AIW uptake would affect the production of these materials. In this experiment, we have tested on ammonium production as explained in the following sections.

Testing methods

Four-week-old male Wistar/ST Clean rats were purchased from Japan SLC Co. Ltd. and were divided into 3 groups of 8 each after preliminary breeding. AIW of pH 9 and 10 was produced by an electrolyzer Mineone ROYAL NDX3 1 OH by Omco Co., Ltd. This model produces AIW by electrolyzing water with calcium lactate added. On the last day of testing, the rats were dissected under Nembutal anesthesia to take blood from the heart by a heparin-treated syringe. As to their organs, the small intestines, cecum and colon plus rectum were taken out from each of them. The cecum was weighed and cleaned with physiological saline after its contents were removed, and the tissue weight was measured after wiping out moisture. Part of cecal contents was measured its pH, and the rest was used to assay ammonium concentration.

The amount of ammonium contained in fresh feces and cecal contents was measured by the Nessler method after collecting it in the extracted samples using Conway's micro-diffusion container. Fecal free-glucose was assayed by the oxygen method after extraction by hot water. Analysis of free amino acids contained in cecal contents was conducted by the Waters PicoTag amino acid analysis system.

Test results and analyses

No difference was found in the rats' weight gain, water and feed intake and feeding efficiency, nor was any particular distinction in appearance identified. The length of the small intestines and colon plus rectum tended to decline in AIW groups.

PH value of cecal contents was higher and the amount of fecal free-glucose tended to be lower in AIW groups than the control group. Since there was no difference in fecal discharge itself, the amount of free-glucose discharged per day was at a low level.

The amount of discharged free-glucose in feces is greater when intestinal fermentation is more intensive, which indicates that intestinal fermentation is more inhibited in AIW groups than the control group.

Ammonium concentration in cecal contents tends to drop down in AIW groups (Fig. 1). This trend was most distinctive in case of fresh feces of one of AIW groups with pH 10 (Fig.2) AIW uptake was found to be inhibitory against ammonium production. In order to study dynamics of amino acids in large intestines, we examined free amino acids in the cecal contents to find out that cysteine level is low in AIW groups whereas isoleucine level is high in one of AIW groups with pH 10, although no significant difference was identified for other amino acids.

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2. "Official Pharmaceutical Guidelines of Japan, Vol. IT" by Japan Public Documents Association, Hirokawa PublIshin Co., 1996
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2. Clinical evaluation of alkaline ionized water for abdominal complaints:

Placebo controlled double blind tests

Hirokazu Tashiro, Tetsuji Hokudo, Hiromi Ono, Yoshihide Fujiyama, Tadao Baba (National Ohkura Hospital, Dept. of Gastroenterology; Institute of Clinical Research, Shiga University of Medical Science, Second Dept. of Internal Medicine)

"Effect of alkaline ionized water on abdominal complaints was evaluated by placebo controlled double blind tests. Overall scores of improvement using alkaline ionized water marked higher than those of placebo controlled group, and its effect proved to be significantly higher especially in slight symptoms of chronic diarrhoea and abdominal complaints in cases of general malaise. Alkaline ionized water group did not get interrupted in the course of the test, nor did it show serious side effects nor abnormal test data. It was confirmed that alkaline ionized water is safer and more effective than placebos.

Summary

Effect of alkaline ionized water on abdominal complaints was clinically examined by double blind tests using clean water as placebo. Overall improvement rate was higher for alkaline ionized water group than placebo group and the former proved to be significantly more effective than the other especially in cases of slight symptoms. Examining improvement rate for each case of chronic diarrhoea, constipation and abdominal complaints, alkaline ionized water group turned out to be more effective than placebo group for chronic diarrhoea, and abdominal complaints.

The test was stopped in one case of chronic diarrhoea, among placebo group due to exacerbation, whereas alkaline ionized water group did not stop testing without serious side effects or abnormal test data in all cases.

It was confirmed that alkaline ionized water is more effective than clean water against chronic diarrhoea, abdominal complaints and overall improvement rate (relief of abdominal complaints) and safer than clean water.

Introduction

Since the approval of alkaline ionized water electrolyzers by Pharmaceutical Affairs Law in 1966 for its antacid effect and efficacy against gastrointestinal disorders including hyperchylia, indigestion, abnormal gastrointestinal fermentation and chronic diarrhoea, they have been extensively used among patients.

However, medical and scientific evaluation of their validity is not established. In our study, we examined clinical effect of alkaline ionized water on gastrointestinal disorders across many symptoms in various facilities. Particularly, we studied safety and usefulness of alkaline ionized water by doubleblind tests using clean water as a control group.

Test subjects and methods

163 patients (34 men, 129 women, age 21 to 72, average 38.6 years old) of indigestion, abnormal gastrointestinal fermentation (with abnormal gas emission and rugitus) and abdominal complaints caused by irregular dejection (chronic diarrhoea, or constipation) were tested as subjects with good informed consent.

Placebo controlled double blind tests were conducted using alkaline ionized water and clean water at multiple facilities. An alkaline ionized water electrolyzer sold commercially was installed with a pump driven calcium dispenser in each of the subject homes. Tested alkaline ionized water had pH at 9.5 and calcium concentration at 30ppm.

Each subject in placebo group used a water purifier that has the same appearance as the electrolyzer and produces clean water.

The tested equipment was randomly assigned by a controller who scaled off the key code which was stored safely until the tests were completed and the seal was opened again.

Water samples were given to each patient in the amount of 200ml in the morning with the total of 500ml or more per day for a month. Before and after the tests, blood, urine and stool were tested and a log was kept on the subjective symptoms, bowel movements and accessory symptoms. After the tests, the results were analyzed based on the log and the test data.

Conclusion

As a result of double blind clinical tests of alkaline ionized water and clean water, alkaline ionized water was proved to be more effective than clean water against chronic diarrhoea, abdominal complaints (dyspepsia) and overall improvement rate (relief from abdominal complaints). Also, safety of alkaline ionized water was confirmed which clinically verifies its usefulness.

3. Effect of Electrolytic Water (Ionized Water) Intake on Lifespan of Autoimmune Disease Prone Mice

Research from Texas University

Recent studies on electrolyzed water indicate that anode or acidic water is most effective as disinfectants; whereas, reduced or alkaline water processed through cathode is used as safe drinking water. The present drinking water study was undertaken in two strains of autoimmune disease prone mice to establish the spontaneous disease process and longevity.

Weanling MRL/lpr and NZBxNZW [B/W] F1 female mice were provided daily with (1) tap water [pH ~7.5, oxygen reduction potential (ORP)~600+] (2) electrolyzed water with pH of ~9.0 and ORP ~400- and (3) hyper-reduced water with pH~10.0 and ORP~600-. Mice were provided H₂O and chow diet ad libitum and weekly body weights and spontaneous deaths were recorded. The mean survival data recorded as days for MRL/lpr mice [25 mice/group] is as follows: (1) tap water 235±25, (2) reduced water 287±40 and (3) hyper-reduced water 346±45 days [<0.05]. In the case of B/W mice [25 mice/group], (1) tap water 269±16, (2) reduced water 298±19 and (3) hyper-reduced 302±18 days. A significantly decreased (<0.05) serum lipid peroxides were observed in mice fed hyper-reduced H₂O. Also, the source of water did not alter lymphocyte subsets or their response to mitogens. In summary, hyper-reduced water with pH~10.0 appears to inhibit autoimmune disease of MRL/lpr mice whereas only a modest increased lifespan was noted for B/W mice. The increased lifespan by electrolyzed H₂O appears to be related to the changes in free radicals and antioxidant enzyme levels. [Supported in part by Zanix Co. and Mr. Waterman Co., Tokyo, Japan].

Summary:

- 1. Life long intake of both reduced (pH 9.0) and hyper-reduced (pH 10.0) water caused no harm to mice compared to tap water.**
- 2. Survival is increased significantly by hyper-reduced water in one strain (MRL/lpr).**
- 3. Slight increased life span in the other strain (NZBxNZW F1).**
- 3. Reduced and hyper-reduced water appears to increase T cell numbers, and decrease B cells.**
- 4. Both reduced and hyper-reduced water appears to increase antioxidant mRNA levels.**
- 5. New clinical and animal studies are needed to confirm above results.**

4. Reduced Water for Prevention of Diseases

Part paper delivered by Dr Shirahata to the Functional Water Symposium in Tokyo by Dr.Sanetaka Shirahata, Graduate school of Genetic Resources Technology, Kyushu University,6-10-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan.

It has long been established that reactive oxygen species (ROS) cause many types of damage to biomolecules and cellular structures, that, in turn result in the development of a variety of pathologic states such as diabetes, cancer and aging. Reduced water is defined as anti-oxidative water produced by reduction of water.

Electrolyzed reduced water (ERW) has been demonstrated to be hydrogen-rich water and can scavenge ROS in vitro (Shirahata et al., 1997). The reduction of proton in water to active hydrogen (atomic hydrogen, hydrogen radical) that can scavenge ROS is very easily caused by a weak current, compared to oxidation of hydroxyl ion to oxygen molecule. Activation of water by magnetic field, collision, minerals etc. will also produce reduced water containing active hydrogen and/or hydrogen molecule.

Several natural waters such as Hita Tenryosui water drawn from deep underground in Hita city in Japan, Nordenau water in Germany and Tlacote water in Mexico are known to alleviate various diseases. We have developed a sensitive method by which we can detect active hydrogen existing in reduced water, and have demonstrated that not only ERW but also natural reduced waters described above contain active hydrogen and scavenge ROS in cultured cells. ROS is known to cause reduction of glucose uptake by inhibiting the insulin-signaling pathway in cultured cells. Reduced water scavenged intracellular ROS and stimulated glucose uptake in the presence or absence of insulin in both rat L6 skeletal muscle cells and mouse 3T3/L1 adipocytes. This insulin-like activity of reduced water was inhibited by wortmannin that is specific inhibitor of PI-3 kinase, a key molecule in insulin signaling pathways.

Reduced water protected insulin-responsive cells from sugar toxicity and improved the damaged sugar tolerance of type 2 diabetes model mice, suggesting that reduced water may improve insulin-independent diabetes mellitus.

Cancer cells are generally exposed to high oxidative stress. Reduced water cause impaired tumor phenotypes of human cancer cells, such as reduced growth rate, morphological changes, reduced colony formation ability in soft agar, passage number-dependent telomere shortening, reduced binding abilities of telomere binding proteins and suppressed metastasis.

Reduced water suppressed the growth of cancer cells transplanted into mice, demonstrating their anticancer effects in vivo. Reduced water will be applicable to not only medicine but also food industries, agriculture, and manufacturing industries.

[Also see above for Dr.Sanetaka Shirahata paper " *Electrolyzed reduced water scavengers active oxygen species and protects DNA from oxidative damage* "]

5. Clinical Improvements Obtained From The Intake Of Reduced Water

Extracts from the *Presentation At The Eight Annual International Symposium On man And His Environment in Health And Disease* on February 24th 1990, at The Grand Kempinski Hotel, Dalls, Texas, USA by *Dr. H. Hayashi, M.D. and Dr. M Kawamura, M.D* ., on:

THE CONCEPT OF PREHEPATIC MEDICINES

Since the introduction of alkaline ionic water in our clinic in 1985, we have had the following interesting clinical experiences in the use of this type of water. By the use of alkaline ionic water for drinking and the preparation of meals for our in-patients, we have noticed :-

- **Declines in blood sugar levels in diabetic patients.**
- **Improvements in peripheral circulation in diabetic gangrene.**
- **Declines in uric acid levels in patients with gout.**

- **Improvements in liver function exams in hepatic disorders.**
- **Improvements in gastroduodenal ulcer and prevention of their recurrences.**
- **Improvements in hypertension and hypotension.**
- **Improvements in allergic disorders such as asthma, urticaria, rhinites and atopic dermatitis.**
- **Improvements in persistent diarrhoea which occurred after gastrectomy.**
- **Quicker improvements in post operative bowel paralysis.**
- **Improvements in serum bilirubin levels in new born babies.**

Being confirming clinical improvements, we have always observed changes of stools of the patients, with the colour of their faeces changing from black-brown colour to a brighter yellow-brown one, and the odour of their faeces becoming almost negligible.

The number of patients complaining of constipation also decreased markedly. The change of stool findings strongly suggests that alkaline ionic water intake can decrease the production of putrefield or pathogenic metabolites.

Devices to produce reduced water were introduced into our clinic in May 1985. Based on the clinical experiences obtained in the past 15 years, it can be said that introduction of electrolyzed-reduced water for drinking and cooking purpose for in-patients should be the very prerequisite in our daily medical practices. Any dietary recipe cannot be a scientific one if property of water is not taken by the patients is not taken into consideration.

The Ministry of Health and Welfare in Japan announced in 1965 that the intake of reduced water is effective for restoration of intestinal flora metabolism.

6. Effects of alkaline ionized water on formation & maintenance of osseous tissues

by Rei Takahashi Zhenhua Zhang Yoshinori Itokawa
(Kyoto University Graduate School of Medicine, Dept. of Pathology and Tumor Biology, Fukui Prefectural University)

Effects of calcium alkaline ionized water on formation and maintenance of osseous tissues in rats were examined. In the absence of calcium in the diet, no apparent calcification was observed with only osteoid formation being prominent. Striking differences were found among groups that were given diets with 30% and 60% calcium. Rats raised by calcium ionized water showed the least osteogenetic disturbance. Tibiae and humeri are more susceptible to calcium deficiency than femora. Theses results may indicate that calcium in drinking water effectively supplements osteogenesis in case of dietary calcium deficiency.

The mechanism involved in osteoid formation such as absorption rate of calcium from the intestine and effects of calcium alkaline ionized drinking water on maintaining bone structure in the process of aging or under the condition of calcium deficiency is investigated.

Osteoporosis that has lately drawn public attention is defined as "conditions of bone brittleness caused by reduction in the amount of bone frames and deterioration of osseous microstructure." Abnormal calcium metabolism has been considered to be one of the factors to contribute to this problem, which in turn is caused by insufficient calcium take in, reduction in enteral absorption rate of calcium and increase in the amount of calcium in urinal discharge. Under normal conditions, bones absorb old bones by regular metabolism through osteoid formation to maintain their strength and function as supporting structure. It is getting clear that remodeling of bones at the tissue level goes through the process of activation, resorption, reversal, matrix synthesis and mineralization. Another important function of bones is storing minerals especially by coordinating with intestines and kidneys to control calcium concentration in the blood. When something happens to this osteo metabolism, it results in abnormal morphological changes. Our analyses have been focusing mostly on the changes in the amount of bones to examine effects of calcium alkaline ionized water on the reaction system of osteo metabolism and its efficiency. Ibis time, however, we studied it further from the standpoint of histology. In other words, we conducted comparative studies on morphological and kinetic changes of osteogenesis by testing alkaline ionized water, tap water and solution of lactate on rats.

Three week old male Wistar rats were divided into 12 groups by conditions of feed and drinking water. Feeds were prepared with 0%, 30%, 60% and 100% of normal amount of calcium and were given freely. Three types of drinking water, tap water (city water, about 6ppm of Ca), calcium lactate solution (Ca=40ppm) and alkaline ionized water (Ca =40ppm, pH=9, produced by an electrolyzer NDX 4 LMC by Omco OMC Co., Ltd.) were also given keely. Rats' weight, amount of drinking water and feed as well as the content of Ca in drinking water were assayed every day. On the 19th and 25th days of testing, tetracycline hydrochloride was added to the feed for 48 hours so as to bring its concentration to 30mg/kg. On the 30th day, blood samples were taken under Nembutal anesthesia, and tibiae, humeri and femora were taken out to make non decalcified samples. Their conditions of osteoid formation and rotation were observed using Villanueva bone stain and Villanueva goldner stain.

Three groups that were given different types of drinking water and the same amount of Ca in the feed were compared to find out no significant difference in the rate of weight gain and intakes of feed and drinking water. Alkaline ionized water group had significantly greater amount of tibiae and humeri with higher concentration of calcium in the bones.

The group of 0% calcium in the feed saw drastic increase in the amount of osteoid. There was not much difference by types of drinking water. Almost no tetracycline was taken into tibiae and humeri, although a small amount was identified in ferora. As a result, osteogenesis went as far as osteoid formation, but it was likely that decalcification has not happened yet, or most of newly formed bones were absorbed.

As to the groups of 30% and 60% calcium in the feed, increase in the area of tetracycline take in was more identifiable with higher clarity in descending order of alkaline ionized water, calcium lactate solution and tap water groups. Especially in case of tap water group, irregularity among the areas of tetracycline take in was distinctive. The group of 100% calcium in the feed saw some improvements in osteogenesis in descending order of alkaline ionized water, calcium lactate solution and tap water. In any case, bone formation seemed to be in good condition at near normal level.

Alkaline ionized water was regarded to be effective for improvements of osteogenesis under the conditions of insufficient calcium in the feed. Also, the extent of dysosteogenesis differed by the region. That is, tibiae and humeri tend to have more significant dysosteogenesis than femora.

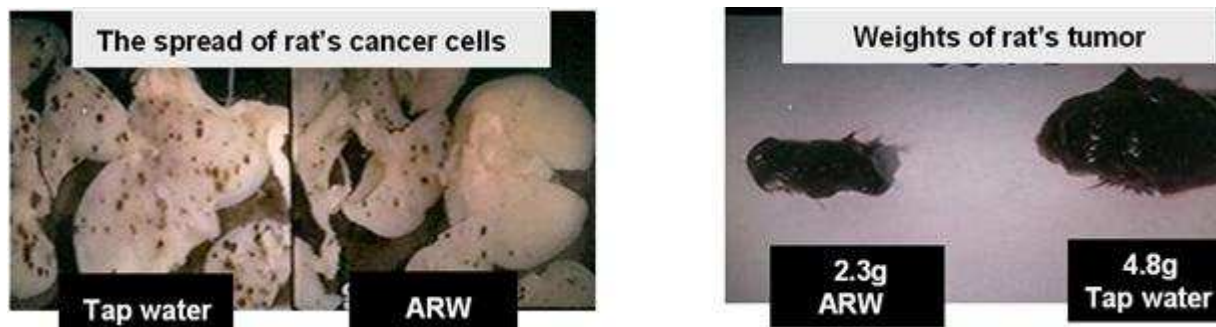
In addition, there is a possibility that osteo metabolism varies depending on enteral absorption rate of calcium, adjustment of discharge from kidneys and functional adjustment of accessory thyroid in the presence of alkaline ionized water. We are now studying its impact on calcium concentration in the blood. We are also examining whether it is possible to deter bone deterioration by testing on fast aging mouse models.

B. Korean Scientific Reports on the Effects of Ionized Water

A short version of this can be seen in our Videos section.

Anti-cancer Effects

After injecting malignant skin cancer cells into cancer-free laboratory mice, they supplied the mice with Alkaline Reduced Water, and compared the size of the tumour after a lapse of 20 days.

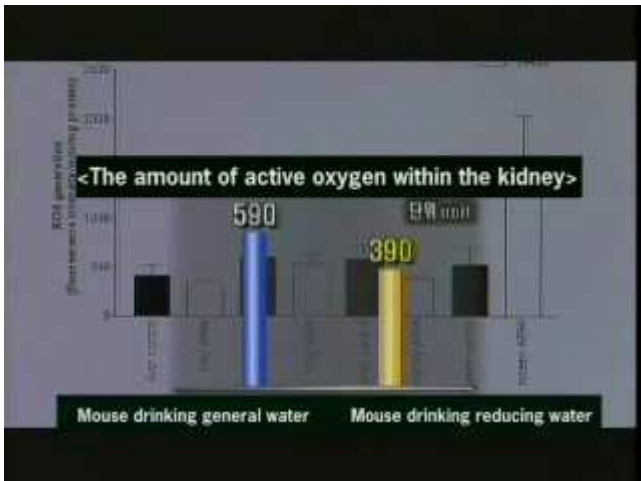


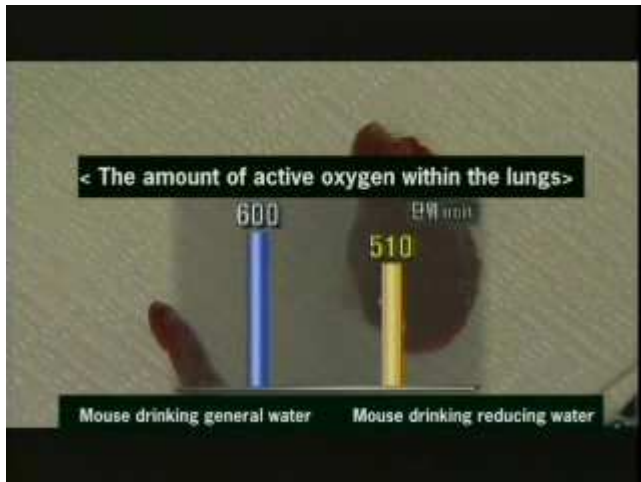
The results showed the mice, which were supplied with the Ionized Water (ARW) showed the growing speed of the **tumour and tumour sizes had been notably reduced** as compared to those that had not taken ARW.

Anti-Oxidization Effects

Mineral Ionized Water (ARW) has action of removing oxygen free radicals. 20 days after injecting skin cancer cells into the tail of cancer-free laboratory mice, the researchers checked the amounts of oxygen free radicals for each separate organ for the mice that had taken normal water and mice that had taken ARW.

Mice that had taken Ionized Water (ARW) showed reduced amounts of oxygen free radicals in their lungs, livers, and kidneys. Nevertheless, in case of the spleen, which has a central roll in immune system, it was discovered that the quantity of oxygen free radical had increased instead for the mice that had taken ARW. And this indirectly reveals that the oxygen free radicals also directly affect the immune system.





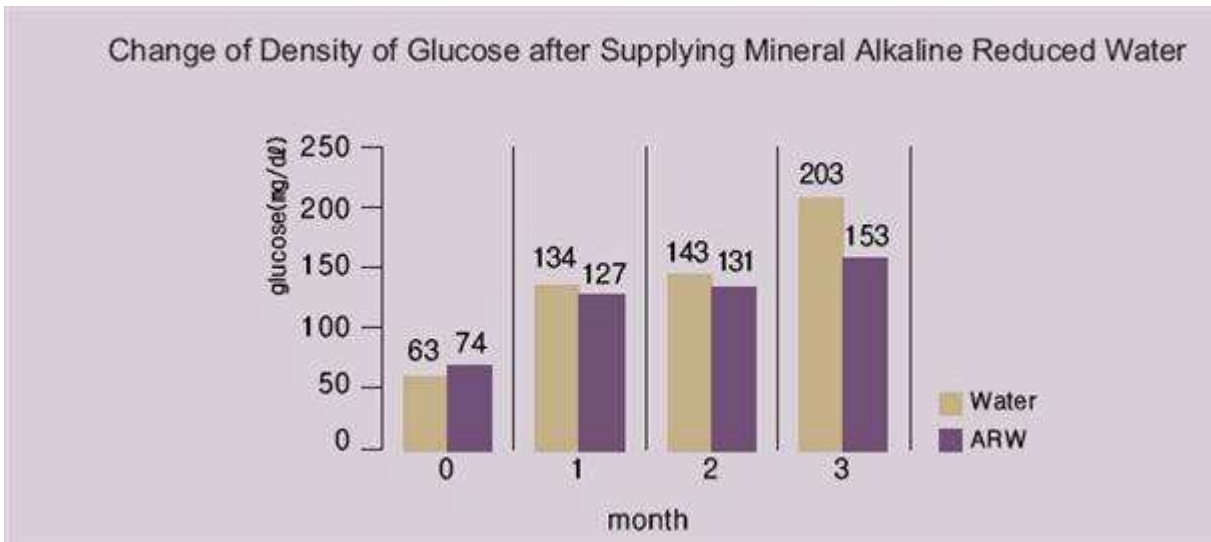
Increase of Immune Function

As the result of investigation conducted on the statistical data concerned, it has been observed that for the case of the mice that had taken ARW, the quantities of interferon gamma (IFN- γ) and interleukin12(1-12) which exercise cellular immune function by attacking bacteria directly and destroying them had been increased. And at the same time the quantities of interleukin (I-4 & II-5) showing antigen-antibody reactions of body fluid immunity, have also been increased.

This suggests that Ionized Water (ARW) could promote the overall immune systems.

Diabetes

For the laboratory mice having genetic disorders that can lead to diabetes, the researchers supplied Alkaline Water for about four months. And compared to those mice that did not have the ARW, blood glucose levels had been reduced, also the amount of harmful triglycerides had been reduced significantly, and overall body weight was stable. It also had shown that the amount of neutral fat had decreased noticeably which is harmful to the body.





Diabetes: The first clinical test conducted in Korea shows that water can control diseases!

3 December 2003: The Natural Medicine Research Institute of Hansuh University had invited 15 patients suffering from diabetes and started a clinical test for them.

The scientists divided the patients into two different groups; they stopped insulin treatment completely for the first group of the patients, and they had them drink the Ionized Water (ARW) instead, and the other group of diabetics had been allowed to continue their hospital treatment as well with receiving insulin as usual.

The blood glucose levels have been lowered on the whole, and the blood glucose levels, which had shown wide variations daily before were being stabilized. But the blood glucose levels for those who had not taken the Ionized Water (ARW) but continued receiving insulin everyday under the hospitalized state continued to show wide variations with their blood glucose level.

7 January 2004: Comparison of blood glucose levels before and after experiment conducted. 5 liters ARW/day administered for the 2nd group of patients.

A significant decrease of blood glucose levels for all patients on AKW. Some exmples are:

1. Patient Lee: 14 years old, blood glucose level : 250

After drinking the Reduced Water for 36 days : blood glucose level : 204

2. Patient Hwang, 17 years old, blood glucose level : 254

After drinking the Reduced Water for 36 days : blood glucose level : 144

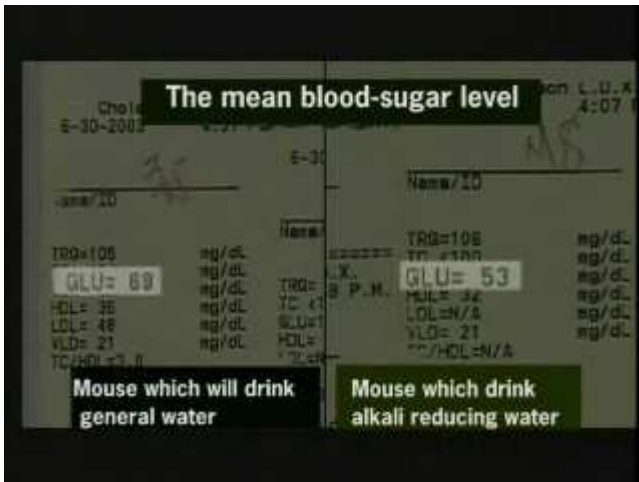
3. Patient Lee2, 9 years old, blood glucose level : 324

After drinking the Reduced Water for 36 days : blood glucose level : 210

4. Patient Lee3: 20 years old, blood glucose level : 400

After drinking the Reduced Water for 36 days : blood glucose level : 168

The experiments indicated that the effectiveness of Ionized Water (ARW) was better than insulin.



Experiment on increased immunity

In a detailed experiment involving 40,000 chicks, they let one group of the chicks drink normal underground water (A-farm) and let the other group (B-farm) drink Mineral ARW.



It was found that **1,100 chicks were dead from the A- farm** where the chicks were supplied with the normal underground water and recorded a survival rate of 94.5%, while the B-farm, where they supplied the Ionized Water (**ARW**) found that **140 chicks were dead**, and therefore recorded a survival rate of 99.3%.

This was a decline in deaths of around 10% from drinking ARW.

This suggested that depending on the kind of water the chicks were drinking, they developed different immunogenic powers.



Protection of DNA in tissues

After mixing DNA extracted from bacteria with the Mineral Ionized Water (ARW) and normal reverse osmosis-filtered water respectively, the researchers generated oxygen free radicals and observed the changes.

It was discovered that the normal water could not protect the DNA from the oxygen free radicals and so the DNA were destroyed, but in the case of ARW, it had protected the DNA from its invasion and the original condition of the DNA was still maintained.



After injecting malignant skin cancer into the body of laboratory mice, they had separated them into two different groups; one group drank the Mineral Ionized Water (ARW) and the other group had to drink normal tap water, and after 20 days they had extracted the internal organs from the mice of the two different groups and carried out measurements on the quantity of the

oxygen free radicals contained in them.

It was discovered that the Ionized Water (ARW) slowed the aging process as well as preventing all kinds of adult diseases by controlling the actions of oxygen free radicals.

The Following Cases Highlight the Antimicrobial Impact of Acid or Low Ph Ionized Water

1. Effects of electrolyzed oxidizing water on reducing *Listeria monocytogenes* contamination on seafood processing surfaces.

Int J Food Microbiol. 2005 Oct 7; [Epub ahead of print]

Liu C , Duan J , Su YC .

College of Food Science and Technology, Shanghai Fisheries University, 334 Jungong Road, Shanghai, 200090, P.R. China.

The effects of electrolyzed oxidizing (EO) water on reducing *Listeria monocytogenes* contamination on seafood processing surfaces were studied. Chips (5x5 cm²) of stainless steel sheet (SS), ceramic tile (CT), and floor tile (FT) with and without crabmeat residue on the surface were inoculated with *L. monocytogenes* and soaked in tap or EO water for 5 min. Viable cells of *L. monocytogenes* were detected on all chip surfaces with or without crabmeat residue after being held at room temperature for 1 h. Soaking contaminated chips in tap water resulted in small-degree reductions of the organism (0.40-0.66 log cfu/chip on clean surfaces and 0.78-1.33 log cfu/chip on dirty surfaces). Treatments of EO water significantly ($p < 0.05$) reduced *L. monocytogenes* on clean surfaces (3.73 log on SS, 4.24 log on CT, and 5.12 log on FT). Presence of crabmeat residue on chip surfaces reduced the effectiveness of EO water on inactivating *Listeria* cells. However, treatments of EO water also resulted in significant reductions of *L. monocytogenes* on dirty surfaces (2.33 log on SS and CT and 1.52 log on FT) when compared with tap water treatments. The antimicrobial activity of EO water was positively correlated with its chlorine content. High oxidation-reduction potential (ORP) of EO water also contributed significantly to its antimicrobial activity against *L. monocytogenes*. EO water was more effective than chlorine water on inactivating *L. monocytogenes* on surfaces and could be used as a chlorine alternative for sanitation purpose. Application of EO water following a thorough cleaning process could greatly reduce *L. monocytogenes* contamination in seafood processing environments.

PMID: 16219378 [PubMed - as supplied by publisher]

2. A clinical study of liver abscesses at the Critical Care and Emergency Center of Iwate Medical University

Nippon Shokakibyō Gakkai Zasshi. 2005 Sep;102(9):1153-60. [Article in Japanese]

Fujino Y , Inoue Y , Onodera M , Yaegashi Y , Sato N , Endo S , Omori H , Suzuki K .

Department of Critical Care Medicine, Iwate Medical University.

We studied 13 emergency cases of liver abscess. Five cases of septic shock or clouding of consciousness were identified on admission. Six patients had diabetes mellitus. Twelve patients met the diagnostic criteria for systemic inflammatory response syndrome, and nine met the criteria for disseminated intravascular coagulation. Plasma endotoxin levels improved rapidly after drainage. Causative organisms were isolated in all patients, and the most common organism was *Klebsiella pneumoniae* (seven cases). Percutaneous transhepatic abscess drainage (PTAD) was performed not only in single cases but also in multiple cases with main huge abscesses. Surgical treatment was performed in the following three cases: a ruptured abscess, an ineffective PTAD, and a case of peritonitis after PTAD. Irrigation of abscesses with strong acidic electrolyzed water revealed a significant decrease in treatment duration. In the majority of our cases, severe conditions were identified on admission. Strong acidic electrolyzed water was useful for management of PTAD.

PMID: 16180673 [PubMed - indexed for MEDLINE]

4. Efficacy of ozonated and electrolyzed oxidative waters to decontaminate hides of cattle before slaughter.

J Food Prot. 2005 Jul;68(7):1393-8.

Bosilevac JM , Shackelford SD , Brichta DM , Koohmaraie M .

US Department of Agriculture, Agricultural Research Service, Roman L. Hruska US Meat Animal Research Center, Clay Center, Nebraska 68933-0166, USA. bosilevac@email.marc.usda.gov

The hides of cattle are the primary source of pathogens such as *Escherichia coli* O157:H7 that contaminate previsceration carcasses during commercial beef processing. A number of interventions that reduce hide contamination and subsequent carcass contamination are currently being developed. The objective of this study was to determine the efficacy of ozonated and electrolyzed oxidizing (EO) waters to decontaminate beef hides and to compare these treatments with similar washing in water without the active antimicrobial compounds. Cattle hides draped over barrels were used as the model system. Ozonated water (2 ppm) was applied at 4,800 kPa (700 lb in²) and 15 degrees C for 10 s. Alkaline EO water and acidic EO water were sequentially applied at 60 degrees C for 10 s at 4,800 and 1,700 kPa (250 lb in²), respectively. Treatment using ozonated water reduced hide aerobic plate counts by 2.1 log CFU/100 cm² and reduced Enterobacteriaceae counts by 3.4 log CFU/100 cm². EO water treatment reduced aerobic plate counts by 3.5 log CFU/100 cm² and reduced Enterobacteriaceae counts by 4.3 log CFU/100 cm². Water controls that matched the wash conditions of the ozonated and EO treatments reduced aerobic plate counts by only 0.5 and 1.0 log CFU/100 cm², respectively, and each reduced Enterobacteriaceae counts by 0.9 log CFU/100 cm². The prevalence of *E. coli* O157 on hides was reduced from 89 to 31% following treatment with ozonated water and from 82 to 35% following EO water treatment. Control wash treatments had no significant effect on the prevalence of *E. coli* O157:H7. These results demonstrate that ozonated and EO waters can be used to decontaminate hides during processing and may be viable treatments for significantly reducing pathogen loads on beef hides, thereby reducing pathogens on beef carcasses.

PMID: 16013376 [PubMed - indexed for MEDLINE]

5. Enhancing the bactericidal effect of electrolyzed water on *Listeria*

monocytogenes biofilms formed on stainless steel.

J Food Prot. 2005 Jul;68(7):1375-80.

Ayebah B , Hung YC , Frank JF .

Department of Food Science and Technology, University of Georgia, 1109 Experiment Street, Griffin, Georgia 30223, USA.

Biofilms are potential sources of contamination to food in processing plants, because they frequently survive sanitizer treatments during cleaning. The objective of this research was to investigate the combined use of alkaline and acidic electrolyzed (EO) water in the inactivation of *Listeria monocytogenes* biofilms on stainless steel surfaces. Biofilms were grown on rectangular stainless steel (type 304, no. 4 finish) coupons (2 by 5 cm) in a 1:10 dilution of tryptic soy broth that contained a five-strain mixture of *L. monocytogenes* for 48 h at 25 degrees C. The coupons with biofilms were then treated with acidic EO water or alkaline EO water or with alkaline EO water followed by acidic EO water produced at 14 and 20 A for 30, 60, and 120 s. Alkaline EO water alone did not produce significant reductions in *L. monocytogenes* biofilms when compared with the control. Treatment with acidic EO water only for 30 to 120 s, on the other hand, reduced the viable bacterial populations in the biofilms by 4.3 to 5.2 log CFU per coupon, whereas the combined treatment of alkaline EO water followed by acidic EO water produced an additional 0.3- to 1.2-log CFU per coupon reduction. The population of *L. monocytogenes* reduced by treatments with acidic EO water increased significantly with increasing time of exposure. However, no significant differences occurred between treatments with EO water produced at 14 and 20 A. Results suggest that alkaline and acidic EO water can be used together to achieve a better inactivation of biofilms than when applied individually.

PMID: 16013373 [PubMed - indexed for MEDLINE]

6. Recent advances in epidemiology and prevention of gastrointestinal endoscopy related infections.

Curr Opin Infect Dis. 2005 Aug;18(4):326-30.

Nelson DB .

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PURPOSE OF REVIEW: This article reviews recent publications relevant to endoscope reprocessing and the potential for transmission of infection during gastrointestinal endoscopy. **RECENT FINDINGS:** There have been a number of established reprocessing failures of gastrointestinal endoscopes at various healthcare facilities across the US resulting in patient notifications. These episodes have been associated with user errors and reprocessing equipment failures, highlighting the need for increased compliance with established guidelines. Surveillance cultures may be useful to monitor the outcome of reprocessing, although their use is controversial. New technology to allow point-of-use monitoring is promising. Biofilm accumulation may be an issue when reprocessing gastrointestinal endoscopes. Although peracetic acid has been promoted as superior to aldehyde-type liquid chemical germicides with regard to soil fixation, it may only be a modest improvement. Electrolyzed acid water is an emerging liquid chemical germicide that may be equivalent to currently accepted disinfectants. There appears to be no benefit to an additional reprocessing cycle before use for endoscopes that have been appropriately cleaned, disinfected, and stored. **SUMMARY:** With the recent media attention on gastrointestinal endoscope reprocessing failures, despite the absence of documented transmission of infection, increased compliance with existing guidelines and new initiatives to enhance endoscope reprocessing are increasingly important to maintain public confidence.

Publication Types:

- Review

PMID: 15985829 [PubMed - indexed for MEDLINE]

7. Microbiological evaluation of gastroscope decontamination by electrolysed acid water (Clentop WM-1)

Arq Gastroenterol. 2005 Jan-Mar;42(1):60-2. Epub 2005 Jun 22. [Article in Portuguese]

Machado AP , Fischman O , Geocze S .

Departamento de Microbiologia, Immunologia e Parasitologia, Escola Paulista de Medicina, Universidade Federal de Sao Paulo, Sao Paulo, SP.

BACKGROUND: The manual disinfection of endoscopes with glutaraldehyde is widely employed. The great routine in gastroenteroscopy services, low number of equipment and the lack of technical knowledge about the decontamination processes are factors that stimulate the inadequate endoscope disinfection, intensifying the risk of transmission of microorganisms. The electrolysed acid water has been effective in the inactivation and destruction of microorganisms. **AIM:** The purpose of this investigation was to verify the microbicidal efficiency of electrolyzed acid water (Cleantop WM-1) to decontaminate gastroscopes after their using in patients. **MATERIAL AND METHODS:** Samples from biopsy channel of flexible endoscopes collected after patient use (n = 20) and after disinfection (n = 20) were cultivated in tryptic soy agar, MacConkey agar and Sabouraud dextrose agar. **RESULTS:** Seventeen of the 20 samples collected after patients examination yielded gram-negative bacilli, gram-positive coccus and yeast cells in contamination of 3 to 5 log₁₀ ufc/mL. Microbial growth was not verified in samples collected after the decontamination process. **Conclusion -** In this preliminary study, the mechanical disinfection carried through the Cleantop device with electrolyzed acid water showed satisfactory results for the elimination of microorganisms and time optimization in the reprocessing of gastroscopes.

Publication Types:

- Evaluation Studies

PMID: 15976913 [PubMed - indexed for MEDLINE]

8. Efficacy of electrolyzed water in inactivating Salmonella enteritidis and Listeria monocytogenes on shell eggs.

J Food Prot. 2005 May;68(5):986-90.

Park CM , Hung YC , Lin CS , Brackett RE .

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

The efficacy of acidic electrolyzed (EO) water produced at three levels of total available chlorine (16, 41, and 77 mg/ liter) and chlorinated water with 45 and 200 mg/liter of residual chlorine was investigated for inactivating *Salmonella* Enteritidis and *Listeria monocytogenes* on shell eggs. An increasing reduction in *Listeria* population was observed with increasing chlorine concentration from 16 to 77 mg/liter and treatment time from 1 to 5 min, resulting in a maximal reduction of 3.70 log CFU per shell egg compared with a deionized water wash for 5 min. There was no significant difference in antibacterial activities against *Salmonella* and *Listeria* at the same treatment time between 45 mg/liter of chlorinated water and 14-A acidic EO water treatment ($P > \text{or} = 0.05$). Chlorinated water (200 mg/liter) wash for 3 and 5 min was the most effective treatment; it reduced mean populations of *Listeria* and *Salmonella* on inoculated eggs by 4.89 and 3.83 log CFU/shell egg, respectively. However, reductions (log CFU/shell egg) of *Listeria* (4.39) and *Salmonella* (3.66) by 1-min alkaline EO water treatment followed by another 1 min of 14-A acidic EO water (41 mg/liter chlorine) treatment had a similar reduction to the 1-min 200 mg/liter chlorinated water treatment for *Listeria* (4.01) and *Salmonella* (3.81). This study demonstrated that a combination of alkaline and acidic EO water wash is equivalent to 200 mg/liter of chlorinated water wash for reducing populations of *Salmonella* Enteritidis and *L. monocytogenes* on shell eggs.

PMID: 15895731 [PubMed - indexed for MEDLINE]

9. Efficacy of electrolyzed oxidizing water for the microbial safety and quality of eggs.

Poult Sci. 2004 Dec;83(12):2071-8.

Bialka KL , Demirci A , Knabel SJ , Patterson PH , Puri VM .

Department of Agricultural & Biological Engineering, The Pennsylvania State University, University Park, Pennsylvania 16802, USA.

During commercial processing, eggs are washed in an alkaline detergent and then rinsed with chlorine to reduce dirt, debris, and microorganism levels. The alkaline and acidic fractions of electrolyzed oxidizing (EO) water have the ability to fit into the 2-step commercial egg washing process easily if proven to be effective. Therefore, the efficacy of EO water to decontaminate *Salmonella* Enteritidis and *Escherichia coli* K12 on artificially inoculated shell eggs was investigated. For the in vitro study, eggs were soaked in alkaline EO water followed by soaking in acidic EO water at various temperatures and times. Treated eggs showed a reduction in population between $> \text{or} = 0.6$ to $> \text{or} = 2.6$ log₁₀ cfu/g of shell for *S. Enteritidis* and $> \text{or} = 0.9$ and $> \text{or} = 2.6$ log₁₀ for *E. coli* K12. Log₁₀ reductions of 1.7 and 2.0 for *S. Enteritidis* and *E. coli* K12, respectively, were observed for typical commercial detergent-sanitizer treatments, whereas log₁₀ reductions of $> \text{or} = 2.1$ and $> \text{or} = 2.3$ for *S. Enteritidis* and *E. coli* K12, respectively, were achieved using the EO water treatment. For the pilot-scale study, both fractions of EO water were compared with the detergent-sanitizer treatment using *E. coli* K12. Log₁₀ reductions of $> \text{or} = 2.98$ and $> \text{or} = 2.91$ were found using the EO water treatment and the detergent-sanitizer treatment, respectively. The effects of 2 treatments on egg quality were investigated. EO water and the detergent-sanitizer treatments did not significantly affect albumen height or eggshell strength; however, there were significant affects on cuticle presence. These results indicate that EO water has the potential to be used as a sanitizing agent for the egg washing process.

Publication Types:

PMID: 15615022 [PubMed - indexed for MEDLINE]

- Evaluation Studies

10. Efficacy of acidic electrolyzed water ice for pathogen control on lettuce.

J Food Prot. 2004 Nov;67(11):2544-9.

Koseki S , Isobe S , Itoh K .

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koseki@nfri.affrc.go.jp

Acidic electrolyzed water (AcEW) was used as frozen AcEW (AcEW-ice) for inactivation of *Listeria monocytogenes* and *Escherichia coli* O157:H7 on lettuce. AcEW-ice was prepared from AcEW with 20, 50, 100, and 200 ppm of available chlorine by freezing at -40 degrees C and generated 30, 70, 150, and 240 ppm of chlorine gas (Cl₂), respectively. The AcEW-ice was placed into styrene-foam containers with lettuce samples at 20 degrees C for 24 h. Although AcEW-ice generating 30 ppm Cl₂ had no effect on *L. monocytogenes* cell counts, AcEW-ice generating 70 to 240 ppm of Cl₂ significantly ($P < 0.05$) reduced *L. monocytogenes* by ca. 1.5 log CFU/g. *E. coli* O157:H7 cell counts were reduced by 1.0 log CFU/g with AcEW-ice generating 30 ppm of Cl₂. AcEW-ice generating 70 and 150 ppm of Cl₂ reduced *E. coli* O157:H7 by 2.0 log CFU/g. Further significant reduction of *E. coli* O157:H7 (2.5 log CFU/g) was demonstrated by treatment with AcEW-ice generating 240 ppm of Cl₂. However, treatment with AcEW-ice generating 240 ppm of Cl₂ resulted in a physiological disorder resembling leaf burn. AcEW-ice that generated less than 150 ppm of Cl₂ had no effect on the surface color of the lettuce. AcEW-ice, regardless of the concentration of the emission of Cl₂, had no effect on the ascorbic acid content in the lettuce. The weight ratio of lettuce to AcEW-ice required was determined to be over 1:10. The bactericidal effect of AcEW-ice appeared within the first 2 h. The use of AcEW-ice provides simultaneously for low temperature storage and inactivation of bacteria.

PMID: 15553639 [PubMed - indexed for MEDLINE]

11. The efficacy of function water (electrolyzed strong acid solution) on open heart surgery; postoperative mediastinitis due to methicillin-resistant *Staphylococcus aureus*

Kyobu Geka. 2004 Nov;57(12):1110-2. [Article in Japanese]

Ichihara T , Fujii G , Eda T , Sasaki M , Ueda Y .

Department of Cardiovascular Surgery, Tosei General Hospital, Seto, Japan.

Methicillin-resistant *Staphylococcus aureus* (MRSA) infection after cardiac surgery has recently increased. We compared the anti-inflammatory effect of an electrolyzed strong acid solution and a warm saline solution in patients with open heart surgery. These solutions were used for mediastinal irrigation before closing the sternum. Group A patients were irrigated by a warm saline solution, and group B patients were irrigated by an electrolyzed strong acid solution, administration of this

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]

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 ≤ 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]

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 .

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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]

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 .**

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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 ($P < \text{or} = 0.05$). 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 ($P < \text{or} = 0.05$). 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]

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 .**

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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]

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 .

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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]

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 .

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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 (10⁶ 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 (10⁵ 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]

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 .

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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]

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 .

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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 found 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]

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 .

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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]

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 .

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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]

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 .**

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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]

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.

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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 (10³) to 10⁴ CFU/g, regardless of the inoculation technique.

PMID: 14627276 [PubMed - indexed for MEDLINE]

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 .

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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

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.

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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 $> 8 \log_{10}$ CFU/ml. EOA and AEOA treatments effectively reduced *L. monocytogenes* populations by $> 8 \log_{10}$ CFU/ml at 25 degrees 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]

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.

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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]

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.

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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]

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 .

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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]

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]

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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]

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

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

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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 ethylene 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]

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 .**

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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]

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 .

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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 10⁴ 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]

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 Repts 1, 2, 3, and 4, respectively. EO water completely eliminated all *Escherichia coli* on 9, 11, 15, and 11 out of 15 eggs in Repts 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]

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

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

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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]

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 .

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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.

PMID: 12412930 [PubMed - indexed for MEDLINE]

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]

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 .

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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]

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 .

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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 $> 9 \log_{10}$ 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 \log_{10} CFU/cm² and by 1.7 to 1.9 \log_{10} CFU/cm², respectively, whereas washing with control water resulted in a reduction of only 0.1 to 0.3 \log_{10} 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 \log_{10} 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]

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 .

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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]

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 .

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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]

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 .

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OBJECTIVE: Observation on the effect of disinfection on gastroscop, 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 gastroscop (average S/N = 5.99) immersed in EOW, HBsAg became negative. **CONCLUSION:** EOW was effective in destroying HBsAg which could be used for gastroscop disinfection.

PMID: 11860842 [PubMed - in process]

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 .**

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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 (AIEW) 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-AIEW 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]

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]

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]

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 .**

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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]

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]

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]

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 .

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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 NaOCl 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]

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 .

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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]

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 .**

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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]

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]

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 and 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]

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 1×10^8 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]

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]

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]

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]

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]

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]

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]

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 ≥ 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]

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]

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]

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 Pseudomonas 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]

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]

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 .

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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]

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.

Department of Endodontics, School of Dentistry, Aichi-Gakuin University, Nagoya, Japan.

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.

PMID: 9927086 [PubMed - indexed for MEDLINE]

[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/cm². **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.

PMID: 11068076 [PubMed - indexed for MEDLINE]

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.

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 log₁₀ CFU/g) in the bacterial load of treated seeds. The reductions for sprouts were between 91.1% and 99.8% (1.05-2.72 log₁₀ 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]

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.

PMID: 12412930 [PubMed - indexed for MEDLINE]

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.

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 dm². 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.

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.

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.

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.

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.

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.

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 (AIEW) at 20°C for 5 min, and subsequently washed with acidic electrolyzed water (AcEW) at 20°C for 5 min. Pre-treatment with AIEW 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 AIEW 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 AIEW as a pre-wash agent, and the effective combined use of AIEW 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

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.

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.

Here is a short video of 3 doctors discussing Kangen Alkaline Water:

http://www.youtube.com/watch?v=T_sM1nuYObk

Here are testimonials from people who have benefitted from drinking Kangen Alkaline water:

<http://I-Beat-Diabetes.com>

<http://I-Beat-Asthma.com>

<http://Cure-Heartburn.com>

