Expert Panel Report: Evaluation of the History and Safety of Ozone in Processing Foods for Human Consumption

Volume 1: Executive Summary

TR-108026-V1
4827

Final Report, May 1997

Prepared by
R & D Enterprises, Inc.
Walnut Creek, California

Prepared for
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
K. R. Amarnath

Customer Systems Group

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

ORGANIZATION(S) THAT PREPARED THIS REPORT

R & D Enterprises, Inc.

ORDERING INFORMATION

Requests for copies of this report should be directed to the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523, (510) 934-4212.

REPORT SUMMARY

Ozone is one of the most effective disinfectants known for deactivation of many organisms, including bacteria, viruses, molds, and insects. Ozone has not been approved for use in food processing in the United States, although it has been used for many years in other countries. An expert panel has carefully reviewed the background, potential food processing applications, and safety of ozone and has declared Generally Recognized As Safe (GRAS) status for ozone use in food processing.

Background

Safe and effective sanitizers are essential for all food processing operations. Stored grain and other food storage applications need protection from insect and mold damage. Environmental and safety concerns about currently used sanitizers and fumigants underscore the need for alternative sanitizer systems. The effective use of electrically generated ozone to disinfect public water supplies in the United States and the long history of safe and effective use in food processing in several other countries prompted a review of the potential for approving the use of ozone for food processing.

Objective

To clarify the regulatory status of ozone and seek Generally Recognized As Safe status for ozone use in food processing in the United States.

Approach

After an initial exploratory meeting with the FDA, EPRI assembled an Expert Panel of outstanding scientists credentialed in food science, ozone technology, food processing, food microbiology, nutrition, toxicology, and pharmacology. This panel conducted an exhaustive search of world literature on ozone from its discovery in 1881 through its adoption and use in food and related processing industries in several countries including France, Japan, and Australia. The Expert Panel met frequently over the course of a year to interpret and evaluate the world-wide data base on the use of ozone.

Results

The Expert Panel Report provides an unequivocal declaration of GRAS status for ozone for use in food processing. This result will be published in a scientific journal; and the full report has been filed with the FDA, thus providing the basis for immediate use of ozone in food processing. The authority for self determination of GRAS based on scientific procedures is stated in the FDC Act at Section 201(s) and 21 C.F.R. 170.30.

Volume 1 of this report includes a Presentation Summary and the Curriculum Vitae of each of the panel members. Volume 2, contains abstracts of the literature assembled for review by the Expert Panel. Volume 3, contains copies of the literature articles cited by the Expert Panel.

EPRI Perspective

The food processing industry is a very important customer group for EPRI member utilities. Food processors are under increased regulation to reduce the amount of chlorine used to treat process water. Ozone is an effective alternative: however, general use has been limited due to inadequate data. This Expert Panel Report will encourage the wider use of ozone for food processing and the reduction of environmentally harmful water discharge. Ozone-based technology will help maintain the competitiveness of the U.S. food processing industry.

TR-108026 V1-V3

Interest Categories

Process industries

Keywords

Ozone
Food processing
Water treatment

PANEL OF FOOD SAFETY EXPERTS

Panel Members (in order of Presentation Summary)

Dee M. Graham, Ph.D., Fellow-I.F.T.
Chair of Panel
R and D Enterprises
2747 Hutchinson Court
Walnut Creek, CA 94598

Michael W. Pariza, Ph.D.
Univ. of Wis. Food Research Institute
1925 Willow Drive
Madison WI 53706

William Howard Glaze, Ph.D.
Univ. NC at Chapel Hill
Environmental Sciences and Engineering
106 Rosenau Hall /Campus Box 7400
Chapel Hill, NC 27599-7400

Gordon W Newell, Ph.D., Fellow-A. T. S.
General and Environmental Toxicology
4163 Hubbart Drive
Palo Alto, CA 94386-3844

John W. Erdman, Jr., Ph.D., Fellow-I.F.T.
Div. of Nutritional Sci., Univ. of Illinois
451 Bevier Hall
905 S. Goodwin Ave.
Urbana, IL 61801

Joseph F. Borzelleca, Ph.D., Fellow-A.T.S., Fellow- I.F.T.
Medical College of Virginia
8718 September Drive
Richmond, VA 23229

Resources in Support of the Panel

Rip G. Rice, Ph. D.
Rice International Consulting Enterprises
1331 Patuxent Drive
Aston, MD 20861 USA

Jeffrey T. Barach, Ph. D.
Vice President of Research and Science Policy
National Food Processors Association
1401 New York Avenue, NW
Washington, DC 20005

Barry Homler, Ph.D.
Director, The EPRI Food Technology Center
1700 North Westwood Avenue
Toledo, OH 43607-1207

Janet Cunningham
Barr Enterprises
PO Box 279
10120 Kelly Road
Walkersville, MD 21783

CONTENTS

SECTION **PAGE**

SECTION **PAGE**

1

EXECUTIVE SUMMARY

Dee M. Graham, Ph. D.

Introduction and Overview

At the request of the Electric Power Research Institute (EPRI), an expert panel was assembled by R & D Enterprises to review the history and health aspects of ozone for its possible use as a sterilant in processing foods for human consumption. The credentials, individual reviews, summary opinion of the Panel, and literature references are presented in this report.

Rapidly increasing population density throughout the world has been accompanied by the evolution of new microbiological strains and their involvement in human illnesses, e.g. *listeria*, virulent strains of *E. coli*, and assorted viruses. The accumulation of toxic chemicals in our environment has increased the national focus on the safe use of sanitizers, bleaching agents, pesticides, and other chemicals in industrial processing.

The increasing need for more sanitizers to control infection and disease concurrent with need to reduce the accumulation of chemical residues to maintain safe air, water, and food supplies is paradoxical. Heavy metal salts, halogen compounds, reducing gases, oxidizers, and alcohols have been used as antimicrobial sanitizers in many specific applications. Chlorine, in gaseous form and other derivatives, e.g., hypochlorite and chlorine dioxide, has been used widely in the U.S. for disinfection of public water supplies and general sanitation. In Europe, especially France, ozone has been a primary sanitizer for public water systems. Certain characteristics of ozone are attractive, and probably safer than other sanitizer systems, leading us to review and evaluate the safety of ozone for use in food processing applications.

General Comments

The following well established characteristics of ozone as a disinfectant appear relevant to the consideration of the safety of ozone for use in food processing:

- Ozone has been shown to be a more powerful disinfectant than the most commonly used disinfectant, chlorine, for deactivation of a very large number of organisms, including the most recalcitrant.

- It is generally accepted that ozone is a powerful disinfectant that has been used safely and effectively in water treatment for nine decades at scales from a few gallons per minute to millions of gallons per day, and is now approved in the U.S. as GRAS for treatment of bottled water and as a sanitizer for process trains in bottled water plants

- There are examples where ozone has been applied in the food industry in Europe for decades, in some cases almost a century.

- Ozonation is the subject of numerous recent investigations for disinfection of foods, including the use of gaseous ozone for increasing storage life, and ozone dissolved in water for sanitizing surfaces of vegetables, fruits, and other agricultural products. These support the position that ozone is a powerful disinfectant.

- Ozone does not remain in water for a very long period of time, thus its use may be considered as a process rather than a food additive with no safety concerns about consumption of residual ozone in food products.

- To the extent that ozone produces byproducts upon treatment of food stuffs, they are similar to normal oxidation products, do not contain chlorine, and are less likely to have deleterious health effects than the byproducts of chlorine treatment.

Background of Ozone Technology

The familiar, fresh, clean smell in air following a thunderstorm characterizes ozone freshly generated in natures environmental factory. Homer noted the smell accompanying a thunderbolt and included his impression in his *Iliad and Odessy* composed in the eighth century BC (Random House, 1950) . The historical background of ozone discovery, generation, determination of physical properties, and reactions was reviewed by Hill and Rice (1982). A U.S. Patent was issued to Fewson (1881) for an apparatus to produce ozone for deodorizing sewer gases. In 1902 Siemens and Halske built their first full-scale ozone generating plant for water treatment in Germany (Kozhinov, 1968). H. *de la Coux* (1904) reported extensive use of ozone for industrial applications including gelatin, casein, and albumin.

In 1906 commercial scale disinfection of potable water with ozone was put into practice in the City of Nice, France where the population increased from 150,000 to 250,000 inhabitants by 1956, and water disinfected daily by ozone increased to 20,000,000 gallons (Lebout, 1959). Ozonation has been adopted as standard practice for water treatment and disinfection by numerous other cities in France, the Netherlands,

Germany, Austria, Switzerland, and many other countries. The first potable water treatment plant to use ozone continuously in the United States was installed in Whiting, Indiana (suburb of Chicago) in 1940. By 1987 over 200 potable water treatment plants in the USA were using ozone (R. G. Rice, Private Communication).

In 1953 ozone-containing air under pressure was found to be more effective than sulfur dioxide for sterilizing empty food containers and was adopted for glass bottles in 1956 in Switzerland (Torricelli, 1959).

Fundamental Chemistry of Ozone Technology

Ozone, O_3 (CAS No. 10028-15-6) is a gas at ambient temperatures and it retains its gaseous state under refrigeration. It is partially soluble in water and, like most gases, its solubility increases as the water temperature decreases. Ozone has the unique property of auto-decomposition, producing numerous free radical species, the most prominent being the hydroxyl free radical (HO) . In the stratosphere, as temperature increases, the rate of ozone decomposition back to its precursor oxygen increases, so that at 35° C the forward and reverse reactions are in equilibrium:

$$3\ O_2 \Leftrightarrow 2\ O_3 + \text{heat and light}$$

As the pH of solutions containing dissolved ozone increases, the rate of decomposition of molecular ozone to produce hydroxyl free radicals also increases, such that at a pH of about 10, ozone decomposes almost instantaneously. The OH^- radical is a more powerful oxidant than ozone, but one with a half-life so short (microseconds) that no significant concentration can occur. This is due to the fact that the OH^- radical reacts rapidly with most organic and many inorganic compounds that may be present. The low concentration and high reactivity of OH^- also means that it cannot have a significant impact on microbes, especially in real-world applications. Thus, the presence of molecular ozone is generally felt to be necessary to ensure microbial sanitation.

The half-life of molecular ozone in air is relatively long (about 12 hours), but in aqueous solution its half-life depends almost entirely upon the amount of ozone-demanding material in the water being ozonized. In other words, the cleaner the water, the lower the content of ozone-demanding materials, and the longer the half-life of ozone. In practice, the half-life of ozone in water can be as short as seconds (e.g., in dirty water or wastewater) or as long as hours (e.g., in clean water used to wash foods).

Ozone is a potent oxidant, fifth in thermodynamic oxidation potential behind elemental fluorine, chlorine trifluoride, atomic oxygen, and hydroxyl free radical. This property makes ozone the most potent oxidizing agent available for water and wastewater treatment, and for disinfection. These two properties, plus the facile ability to produce

the hydroxyl free radical, make ozone an attractive chemical for the protection and preservation of foodstuffs.

In nature, ozone is produced when the sun's energetic ultraviolet radiation first encounters oxygen in the earth's atmosphere. Oxygen molecules are ruptured producing oxygen fragments which, upon encountering another oxygen molecule unite to produce molecular ozone, O_3. More high energy UV rays interact with ozone molecules, destroying them in the process. However, as a consequence of this interaction, most of the most energetic of the sun's UV rays are absorbed and thus prevented from passing through the upper, then the lower stratosphere and reaching the earth's surface. Consequently, the equilibrium set up by the formation and destruction of the earth's stratospheric ozone layer serves as a shield to protect the earth and its many species from the harmful effects of the sun's most energetic UV rays.

At ground level, ozone is produced when lightning is discharged through the atmosphere. The very high energy associated with an electrical discharge sufficient to produce lightning also creates a number of by-products including ozone.

Ozone also is produced at ground level as a by-product of a series of complex gas-phase photochemical oxidations involving hydrocarbons, oxygen, and nitrogen. Photochemical exposure of organic hydrocarbons (e.g. in automobile exhausts, industrial processing plants, forests, volcanic action) in the atmosphere creates mixtures of peroxy-nitrogen-containing organics. Continued photochemical reactions decompose these reactive intermediates, some of which liberate ozone which then becomes a component of "photochemical smog".

Ozone is produced commercially by the decomposition of oxygen molecules to form two oxygen atoms each of which can combine with oxygen (O_2) either in an electric discharge or by UV radiation. In either case, O_2 decomposes to form two oxygen atoms each of which can combine with another O_2 molecule to form ozone (O_3). Ultraviolet bulbs with wavelength emissions below 200 nm, create concentrations of ozone in the range of 0.1% by weight or about 1200 ppm. Such UV bulbs generating relatively low levels of ozone have been used for years to provide low levels of ozone in air in cold storage rooms (e.g., meat and egg storage).

For higher concentrations of ozone in air or oxygen required for commercial applications, the corona discharge technique commonly is employed. Two flat plate electrodes (which can be rolled into cylindrical tubes) are positioned close together and separated by a dielectric material (e.g., glass or ceramic) and a narrow discharge gap. Upon passage of high voltage across the discharge gap, a continuous corona is produced in which oxygen being passed through the gap is exposed. By corona discharge techniques, concentrations of ozone in the gas exiting the ozone generator can reach 18% by weight (18 x 12,000 or about 216,000 ppm).

Applicability of Ozone to the Food Industry

Many applications in the food industry appear appropriate for the use of ozone. These include, e.g., increasing the yield of certain crops, protection of raw agricultural commodities during storage and transit, sanitizing water used for washing food equipment and foods, and packaging materials in which foods products are stored.

Interestingly, in Europe ozone was preferred initially as the safest method for treating and sanitizing public water supplies. However, the broad scale production of poisonous gases for use in World War I led to cheaper production of chlorine gas, which was generally considered more toxic and more hazardous to use than ozone. However, the lower production cost of chlorine gas and its ability to maintain a residual concentration in distribution systems led many cities to adopt chlorine instead of higher cost ozone, except in France where ozone continued to be the preferred water treatment method and sanitizer in spite of its higher cost. The benefits of ozone treatment included sanitizing contaminated water, clarification of heavily turbid water, and deodorization.

Although ozone treatment continues to be more expensive to install than chlorination, improvements in ozone generators, better controls, increasing concerns about the hazards of storing large supplies of toxic chlorine gas in high population areas, the handling and disposal of corrosive chemicals required for on-site generation of chlorine, the demonstrated superiority of ozone for deactivation of some recalcitrant organisms such as *Giardia* and *Cryptosporidium* , and the safety concerns about organic chlorine by-products argue strongly for consideration of ozone on a chlorine-equivalency basis, as a possible safer alternative disinfectant.

In evaluating ozone as a potential alternative to chlorine, the Food Manufacturing Coalition stated: "Any new technology should be as effective as chlorinated solutions in reducing microbial (especially bacterial) contamination and able to meet USDA standards for microbial count reduction in the particular industry, whether poultry, beef, dairy or other" (Food Manufacturing Coalition, 1996).

Many public water treatment ordinances in the U.S. recognize ozonation as an effective sanitizing process, followed by addition of chlorine or chloramine to provide a trace residual of 0.1 to 0.2 ppm at the tap.

Ozonation is recognized by the U. S. Food and Drug Administration as GRAS for treatment of bottled water for drinking when used in accordance with good manufacturing practices (Federal Register, 1982 and 1995). The use of gaseous ozone up to 0.1 ppm in meat aging coolers has been accepted by FDA (Ronk, 1975).

In France, Germany, The Netherlands, The United Kingdom, Scandinavia, Japan, and other countries, ozone has long been used for various applications including air

purification, as well as for storage of meat, fruit, cheese and other products (Easton, 1951). The official standards for food processing in France, Japan, and Australia include the approval of ozone as detailed later in this report. Current programs in the USA include the U.S. Fish and Wildlife Service's Coleman Fish Hatchery using ozonation to inactivate viruses, bacteria, and parasites for protection of spawning salmon (Jennings, 1996); decontamination of beef carcasses (Reagan, et al., 1996); and in Israel control of post harvest decay of table grapes (Sarig, et al., 1996).

Opinion of the Panel

The appropriateness of GRAS affirmation for use of ozone in food processing was evaluated by the Expert Panel. The Panel reviewed published data describing ozone and its methods of production, history of prior use, studies on the efficacy of ozone in food processing, areas of application, safety issues and toxicology, and impact on nutrients. The available body of data, as well as the judgment and experience of panel members, the reported information on uses in other countries, and group deliberations of the panel were combined to formulate the opinion of the panel which is summarized in the final chapter of this report.

Based on its critical evaluation of available information, the Expert Panel has concluded that:

The available information supports the safety of ozone when used as a food disinfectant or sanitizer; and further that the available information supports a Generally Recognized As Safe (GRAS) classification of Ozone as a disinfectant or sanitizer for foods when used at levels and by methods of application consistent with Good Manufacturing Practices.

Bibliography

De la Coux, H. , **1904.** *L'Ozone et ses Applications Industrielles* (Paris, France: Vve. Ch. Dunod) *, p. 49.*

Easton, T. , **1951**. "The Uses of Ozone." *Australian Journal of Dairy Technology*, 4(6): 142-143.

Federal Register, **1982**. Vol. 47, No. 215, Friday, November 5, pp. 50209-50210.

Federal Register, **1995**. Vol. 60, No. 128, Monday Nov. 13, pp. 57075-57130.

Fewson, H., **1881.** U.S. Patent 387,286.

Food Manufacturing Coalition. , **1996**. "Food Innovation and Technology Transfer: Management of Chlorine in Production Processes." National Food Processors Association, July 1 (contact: Ronald J. Phillips, P. O. Box 741, Great Falls, VA 22066)..

Hill, A. G. and R.G. Rice, **1982.** in Rice, R. G. and A. Netzer, Editors, *Handbook of Ozone Technology and Applications* , Volume 1 (Ann Arbor, MI: Ann Arbor Science Publishers) , pp. 1-37.

Jennings, R. , **1996**. "Ozone Water Treatment to Aid Habitat of Salmon." *Contra Costa Times*, Concord, CA, Nov. 15 .

Kozhinov, V. F., **1968.** *Equipment for the Ozonation of Water. (*Moscow, Russia: Publishing House on the Literature of Construction). .

Lebout, Henri, **1959**. "Fifty Years of Ozonation at Nice." in *Ozone Chemistry and Technology , Advances in Chemistry Series* (Washington, DC: American Chemical Society), Vol. 21, *pp.450-452.*

Random House, **1950**. Homer, *Iliad 8:135, 14:415; Odyssey 12:417, 14:307; The Complete Works of Homer,* Modern Library Edition (New York, NY: Random House).

Reagan, J. O.; Acuff, G.R.; Bulge, D.R.; Buyck, N. J.; Dickson, J.S.; Kastner, C. L.; Massden, J.L.; Morgan, J.B.; Nickelson, R.II; Smith, G.C.; and Sofas, J.N., **1996**. "Trimming and Washing of Beef Carcasses as a Method of Improving the Microbiological Quality of Meat." *Journal of Food Protection* 59(7): pp. 751-756.

Ronk, R. , **1975. "**Status of ozone for water treatment and food processing under the Federal FD&C Act." In *Proc. First International Symposium on Ozone for Water and Waste*

Water Treatment (Waterbury, CT: The International Ozone Institute, , --now Stamford, CT: Intl. Ozone Assoc.,), pp. 830-842.

Sarig, P.; T. Zahavi ; Y. Zutkhi ; S. Yannai ; N. Lisher ; and R. Ben-Arie ,**1996**."Ozone for Control and Post-Harvest Decay of Table Grapes Caused by *Rhizopus stolonifer*." *Physiological and Molecular Plant Pathology*, 48(6): 403-415 .

Torricelli , Alfred, **1959**. "Sterilization of Empty Containers for Food Industry." in *Ozone Chemistry and Toxicology* (Washington, DC: Am. Chem. Soc.), pp. 375-380 .

2

EFFICACY OF OZONE IN FOOD PROCESSING

Michael W. Pariza, Ph. D.

Ozone is effective in killing bacteria, molds, yeast, viruses and parasites (Morris, 1975) (International Ozone Association, 1990). Its effectiveness is influenced by pH and temperature in that these variables affect the solubility and the rates of decomposition and spurious chemical reactions of ozone (NFPA, 1978; Ewell, 1940). The next section deals with this in more detail.

Ozone is reported to be effective against enteric viruses including polio-, coxsackie-, echo- and hepatitis A viruses (Burleson et al., 1975; Arimoto et al., 1996; Sproul, 1975; Snyder, et al., 1975; Shinriki et al., 1981; Shinriki, et al., 1988). Susceptibility to ozone varies with microbial species. In general, higher concentrations are required to kill molds and spore-forming bacteria than to inactivate non-sporeforming bacteria, especially gram negative pathogens such as *Escherichia coli* and *Salmonella* (NFPA, 1978; Ito and Seeger, 1980).

Effectiveness of ozone against microbial pathogens and spoilage organisms in food systems has been studied (Beuchat, 1992). It has been used to preserve fish, poultry, bacon, butter, cheese, eggs, mushrooms, potatoes and fruits, and to reduce aflatoxin in peanuts and cottonseed meals. Because it is a powerful oxidizing agent, ozone also may cause rancidity in fat-containing foods.

Ozone is particularly effective in citrus fruits and berries (Sarig et al., 1996; Beuchat, 1992). Ozone also impedes the ripening action of ethylene by destroying it, which allows extension of shelf-life for some fruits and vegetables (e.g., bananas and tomatoes) (Gane, 1936).

Ozone is reported to be effective in reducing pathogen load, including *Salmonella,* in raw poultry (FSIS, 1986) and seafood (Chen et al., 1987), and spoilage organisms in grains, dried legumes and spices (Naitoh et al., 1987). It has been used successfully to reduce levels of airborne bacteria, yeast and mold in a confectionery plant (Naitoh, 1989). Ozone has also been used to reduce levels of microbial contamination of beef carcasses (Reagan et al., 1996).

The application of ozone to food systems involves a balance between microbial killing and issues of food quality. A case in point is the potential use of ozone to reduce pathogen load in poultry processing (FSIS, 1986). There are two ways ozone could be used: to decontaminate spent chiller water for recycling back into the chilling operation, and to directly decontaminate water as it is being used to rinse carcasses.

Ozone use on spent chiller water is the less problematic, since food surfaces do not come into direct contact with the gas. It is in fact quite analogous to the use of ozone to decontaminate river water for drinking, which of course has a long history of safe use.

However, ozone use to directly decontaminate poultry carcasses presents additional challenges. It effectiveness as a "direct contact" antimicrobial agent should be balanced against the possibility of unacceptable changes in organoleptic character and, most importantly, the possible formation of uncharacterized oxidation products in the food itself. Again, in considering these issues, one should keep in mind the problematic effects of the major alternative-- chlorine. A direct comparison of chlorine and ozone in direct food use as regards efficacy and chemistry/quality/toxicology is, therefore, in order. These issues are considered in the following chapters. In this regard it is worth noting that the Japanese, French and Australian governments have approved ozone as a food processing aid (Japan, 1995, 1995a, 1996; France, 1995; Australia, 1996). Moreover, ozone is also listed in Food Chemicals Codex (FCC, 1996).

Bibliography

Arimoto, M., J. Sato, K . Maruyama., G. Mimura, I. Furusawa, **1996.** "Effect of chemical and physical treatments on the inactivation of striped jack nervous necrosis virus (SJNNV)," *Aquaculture* 143 (1):15-22..

Australian Food Standards Code, **1996**. STANDARD A 16, "Processing Aids; Amendment 29 to Foods Section, Table II, Group II," in *Commonwealth of Australia Gazette*, April 4, pp. 15-40.

Beuchat, L.R., **1992**. "Surface disinfection of raw produce." *Dairy Food Environ. Sanit. 12: 6-9.*

Burleson, G.R., T. M. Murray., and M. Pollard , **1975**. "Inactivation of viruses and bacteria by ozone, with and without sonication." *Appl. Micro. 29: 340-344.*

Chen, H. C., S.O. Chang,., and S.T. Ing , **1987**. "A study of the sterilization effect of ozone and its application for marine food processing." *J. Fish. Soc. Taiwan 14(2): 79-89.*

Ewell, A.W., **1940**. "Ozone and light in refrigeration." *Refrigeration Databook* (1940) pp. 199-203.

Food Chemicals Codex, **1996**. "Monograph Specifications . Ozone: Triatomic Oxygen." Institute of Medicine, p.267, 4TH edition (Washington, DC, National Academy Press,1996), 882 pages.

FSIS, **1986**. "Ozone-- A potential alternative to chlorine for water disinfection." (Washington, DC: USDA-FSIS: Memorandum on Screening for Salmonella in Poultry Processing) Vol. 5 No. 3, pp. 5-6.

France, **1995**, "Decree of 23 February 1995 relative to various technological additives in human foods." *Journal Officiel de la Republique Francaise 4 Mars , **1995.*** P. 3457.

Gane, R, **1936**. "The respiration of bananas in presence of ethylene." *New* Phytologist 36: 170-178.

International Ozone Association, **1990**.-in Proceedings, 1990 Spring Conference, "New Developments: Ozone in Water and Wastewater Treatment"' March 27-29, Shreveport, LA (Stamford, CT: Intl. Ozone Assoc.),pp. 327-336, 381-389, 391-412.

Ito, K.,A., and M. L. Seeger, **1980**. "Effects of germicides on microorganisms in can cooling waters." *J. Food Prot. 43: 484-487.*

Japan, **1995**. Prime Minister of Japan. " Law # 101: Proclamation of the change of May 24, of a portion of Food Hygiene Law and Nutrition Improvement Law." *Official Report* # 165, Printing Office of Treasury Ministry, May 24.

Japan, **1995a**. Ministry of Welfare, "Notification # 160: List of Additives Already in Existence." *Official Report* # 151, Printing Office of Treasury Ministry, August 10 (extra).

Japan, **1996**. Ministry of Welfare, "Notification # 120: List of Additives Already in Existence."

Official Report # 90, Printing Office of Treasury Ministry, April 16 (extra).

Morris, J.C., **1975**. **"**Aspects of the quantitative assessment of germicidal efficacy," -in Disinfection Water and Wastewater, J. D. Johnson, Editor (Ann Arbor, MI: Ann Arbor Science Publishers, Inc., 1975, pp. 1-10.

Naitoh, S., **1989**. "Studies on utilization of ozone in food preservation, effect of ozone treatment on airborne microorganisms in a confectionery plant." J. *Antibact. Antifung. Agents 17: 483-489.*

Naitoh, S., Y. Okada, and T. Sakai, **1987**. "Microbiocidal properties of ozone on cereal grains, cereal grain powders, peas, beans, and whole spices." *Nippon Shokuhin Kogyo Gakkaishi* 34: 788-793.

NFPA, **1978**. "Resistance to Germicides." The NFPA Research Laboratories in 1978, pp. 39-41.

Reagan, J. D., G. R. Acuff, D. R. Buege, D. R. Buyck, J. S. Dickson, C. L. Kastner, J. L. Marsden, J. B. Morgan, R. Nickelson, G. C. Smith, and J. N. Sofos, **1996**. "Trimming and washing of beef carcasses as a method of improving the microbiological quality of meat." *J. Food Prot.* 59: 751-755.

Sarig, P.,T. Zahav , Y. Zutkhi , S. Yanna, N. Lisker, and R. Ben-Arie , **1996**. "Ozone for control of post-harvest decay of table grapes caused by *Rhizopus slotenifer*. " *Physiol. Mol. Plant Pathol.* 48: 403-415.

Shinriki, N., K. Ishizaki, A. Ikehata, T. Yoshizaki, A. Nomura, K. Miura, and Y. Mizuno, **1981**. "Degradation of Nucleic Acids with Ozone. II. Degradation of Yeast RNA, Yeast Phenylalanine tRNA and Tobacco Mosaic Virus RNA." *Biochemica et Biophysica Acta.*, 655:323-328.

Shinriki, N., Ishizaki, K, Yoshizaki, T., Miura, K., and Ueda, T, **1988**. ".Mechanism of Inactivation of Tobacco Mosaic Virus with Ozone." *Wat. Res.,*. 22(7): 933-938.

Snyder, J.E., and P.W. Chang, **1975**. "Relative Resistance of Eight Human Enteric Viruses to Ozonization in Saugatucket River Water." International Ozone Institute Workshop Series: *Aquatic Applications of Ozone. Ed. W.J.* Blogoslawski, R.G. Rice (Stamford, CT: Intl. Ozone Association, Pan American Group).

Sproul, O.J. , **1975.** " Virus Inactivation by Ozone" in Aquatic Applications of Ozone, W.J. Blogoslawski & R.G. Rice, Editors (Stamford, CT; International Ozone Assoc., Pan American Group, 1975), pp. 16-24.

3

APPLICATIONS FOR OZONE IN THE FOOD INDUSTRY

William H. Glaze, Ph. D.

Applications of Ozonated Water in the Food Industry

Introduction. It is well known that ozone is a more effective disinfectant for most organisms in water than chlorine and far more so than hydrogen peroxide and chloramines. However, ozone is so reactive that it may be consumed by chemicals in the background before it can deactivate organisms. This is often referred to as "ozone demand," but in a complex matrix the reaction of ozone with background materials is not an instantaneous process that once finished, leaves a residual of ozone for disinfection purposes. Rather, ozone continues to react with background materials, usually organics, and its lifetime is diminished. Thus, in complex matrices such as wastewater, ozone will have a short lifetime and higher doses will be required for a given disinfection target. For this reason, ozone has seen limited use as a disinfectant or as an oxidant of specific compounds in concentrated wastewaters.

The lifetime of ozone in water is also influenced by pH since hydroxyl ions will accelerate its decomposition which occurs through a complex, chain radical mechanism. Therefore, even in relatively pure water, ozone has a finite lifetime which is longer at pH values below neutrality. Also, substances such as carbonate ions that interrupt the chain radical ozone decomposition process will extend the lifetime and the disinfection efficacy of ozone.

All of this means that ozone will not be as stable as chlorine and higher doses generally will be required than one would predict based on its high reactivity. Still, ozone is such a strong oxidant and disinfectant that it is usually competitive with chlorine for disinfection purposes, certainly for recalcitrant organisms such as spore and cyst formers, and parasites.

Ozone technology is more complicated than chlorine technology and subject to errors of inadequately trained personnel, including academic researchers. Ozone transfer into the liquid phase is not as facile as chlorine dissolution, involving the transfer of ozone from the gas phase in a bubble into the liquid phase. This process, and the concentration of ozone in water that can be achieved, is affected by bubble size, gas:liquid volume ratio, ozone concentration in the gas phase, temperature, materials of construction, and

as noted above, pH and other characteristics of the water phase. Unfortunately, not all investigators and technicians who carry out ozone disinfection studies have appreciated these subtleties, and ozone disinfection (or kinetics) studies have often been badly done. Moreover, ozone equipment has to be designed carefully and maintained to ensure efficient generation and transfer of ozone for long periods of time. For these reasons, it is often difficult to know if a study was well conceived and executed. For example, in Ong et al. (1996), aqueous ozone (0.25 mg/L) was found less effective than hypochlorite ion (500 mg/L) for pesticide removal from fresh apples, undoubtedly due in part to the very low concentration of ozone achieved in the solution, far below levels achievable by off-the-shelf technology. On the other hand, Gorman et al. (1995) report the use of 0.5% ozone for sanitizing beef briskets, far above the solubility limit for ozone in water under realistic conditions. Presumably, the authors mean that gaseous ozone at 0.5% (by weight) was added to water, but the concentration in the liquid phase, which is most critical to an understanding of disinfection efficacy, was not measured.

Early References to the Decontamination of Fish and Shellfish with Ozonated Water. The earliest published accounts of the use of ozonated water in food treatment appear to be in the area of fish and shellfish preservation. In 1929, Violle performed experiments on the ozonation of seawater spiked with various bacteria (*B. typhus, B. coli*, etc.) and found that sterilization resulted that was comparable to what was obtained in fresh water (Violle, 1929). Further experiments showed that exposure of shellfish to ozonated water did not affect the taste, "protoplasm" or appearance of the shellfish. Thus, Violle concluded that preozonation of water was a suitable treatment for depuration of shellfish. In 1936, J. Salmon and J. Le Gall built upon this work, reporting that fresh fish (whiting) stored under ozonated ice were edible for between 12 and 16 days whereas fish treated with sterilized ice (presumably sterilized with hypochlorous acid) were inedible after the 12th day, and possibly after the 8th day (Salmon and Le Gall, 1936). Preliminary washing of the fish with ozonated water extended the shelf life of the fish for a little over five days. In subsequent work by the same group, samples of lots of oysters, mussels and other varied shellfish were pre-rinsed in ordinary seawater, depurated in ozonated seawater for a specified period of time, then opened under aseptic conditions and their contents assayed by various tests for evidence of total and pathogenic organisms (Salmon et al., 1937a, 1937b). According to the authors, the work was carried out "under conditions more closely (than Violle's) approaching industrial practice". The experimental results showed that ozonated water depurated contaminated shellfish more rapidly than control samples. Salmon et al. refer to pending requests that the ozonation process be approved by local and federal governments and indicate that a system was installed in Le Havre for the daily cleansing of 2,000 kg of shellfish and at Boulogne-sur-Mer for 6,000 kg (Salmon et al. 1937b).

In a series of papers from 1963 to 1979, Fauvel reinvestigated the use of ozone for the same purposes (Fauvel, 1963; 1972; 1977; Fauvel et al., 1979). In his 1963 paper Fauvel examined the efficacy of chlorine vs. ozone in the decontamination of mussels and

clams spiked with *E. coli*. The results showed that ozone was superior to chlorine in terms of the levels of *E. coli* found after successive storage times in both the flesh and intervalvular liquid. In the 1972 paper, Fauvel noted that the ozonization process had been put "into industrial use - it is currently in use in one of the cleansing stations on the Mediterranean coast, that of the 'Dauphin' at Sète" In this paper, Fauvel reported on the evaluation of the Sète operation by assaying 17 lots of clams and 16 lots of mussels. Shellfish flesh and intervalvular water were assayed for *E. coli* before and after 24 hour treatments with ozonized seawater. For more highly contaminated clams (50-75,000 *E. coli* per liter) a minimum of 4 days treatment was needed for complete elimination of contamination. Slightly shorter times (3 days) were required for mussels. *For clams with a similar level of contamination, a minimum of 6 days treatment with chlorinated water was required to obtain similar results*, a point reemphasized in Fauvel's review article of 1977. The ozone required was estimated by the reported production rate of the ozone generator; for water containing 2,000 - 5,000 *E. coli* per liter, the dose was 1.50 - 2.10 gm/m^3 (NOTE: "dose" is preferred to "concentration" since ozone often decays rapidly and concentration can only be defined under steady state conditions) Fauvel et al. (1979) described the Cote Bleue shellfish purification process and in laboratory studies showed that when ozone is added to seawater, it quickly reacts with bromide ion and other substances present to form active bromine compounds. No bromate ion was found by a polarographic method.

More recent studies on the treatment of fish and shellfish include comparisons of ozone and chlorine for scallop depuration at a La Paz, Mexico aquaculture facility. Both were found to be effective, reducing total plate counts by 90-94 % (Blogoslawski and Monasterio, 1982). *In each case, ozone was slightly more efficacious than chlorine (both in the range of 0.5 to 3.0 ppm).* Chen et al. determined the effects of ozone on shrimp that had been spiked with nine bacterial strains (including *E. coli, Pseudomonas aeruginosa, and Salmonella typhimurium*). In preliminary work, a 1-hr flushing of shrimp meat with a 2% saline solution containing 5.2 mg/L ozone reduced *E. coli* levels by 98.5% (Chen et al., 1987). A more definitive study showed that ozonation in a saline solution was more effective than in water containing organic compounds and that no mutagens were found after ozonation of the flesh (Chen et al., 1992). DeWitt et al. (1984) studied the effects of storage of *unpeeled* shrimp on ozonated ice and also prerinsing with ozonated water (concentrations unspecified). Following storage for 18 days, samples stored on ozonated ice made on-site had "perhaps" 1-2 days extension of shelf life, but overall it appeared that storage over ozonated ice was not advantageous. Haraguchi et al. (1969) studied viable bacterial counts on the skin surface of gutted fish immersed in a 3% NaCl solution containing 0.6 mg/L of ozone for 30-60 minutes. Levels of twenty-three organisms (including *Staphylococci, Bacillus, E. coli, Pseudomonas, Flavobacterium, Vibrio, Aspergillus, etc.)* were studied and counts were reported to decrease by 1/100 to 1/1,000 of those of control fish. Lee and Kramer (1984) carried out a similar study with sockeye salmon. In ice made from either chlorinated or ozonated water the microbial counts increased to 10^6/g in ten days, 10^7/g in 14 days and 10^9/g in 21 days.

In summary, it appears that the treatment of shellfish with ozonated seawater results in accelerated depuration and that this has been a commercial process in France for decades. Blogoslawski et al. (1993) have reviewed this area and in new experiments have shown that ozone treatment of sea water reduces the level of *Vibrio* bacteria in the presence of shrimp larvae. For example, 17 ppm total oxidant residuals after introduction of ozone resulted in reduction of the bacterium from TCBS medium at 10^{-1} dilution to non-detectable levels. It is clear that ozone added to sea water in these concentrations reacts rapidly with sea water bromide to give higher oxidation states of bromine, including hypobromous acid.

In any case, the result is shellfish which are less hazardous for human consumption. Washing fresh fish with fresh ozonated water, also is effective in reducing microbial counts and lengthening the storage time of the product; ozonated water is at least as effective as chlorinated water. Ozonated (or chlorinated ice) does not spectacularly increase the storage time of fresh fish, possibly due to the loss of active ozone during the manufacture and/or storage of the ice.

More Recent Studies on the Use of Ozonated Water in the Food Industry. Several controlled studies have been reported in the food science literature that were designed to evaluate the efficacy of treatment of fruits and vegetables with ozonated water. Kondo et al. (1989) observed greater than 90% reduction of total bacterial counts upon treatment of Chinese cabbages with ozonized water (2.3 mg/L) at 6°C for 60 minutes. Spotts and Cervantes (1992) compared ozonated and chlorinated water for spore inhibition on pears in a packinghouse test and found ozone was either comparable to or slightly less effective than chlorination for inhibition of *Alternaria spp., Cladosporium and Penicillium spp.*

Spray washing of beef carcasses with water was studied as a result of *E. coli* contamination episodes in the Pacific Northwest in 1993 (Smith et al. 1995). Pressure washing reduced microbial counts per square cm of carcass surface by more than 3 log cycles. The incremental benefit of using hydrogen peroxide or ozonated water in the second wash cycle was not clear in the abstract.

There is also much interest in the treatment and recycle of wash water in the carrot industry. Studies were carried out under industry sponsorship at Calif. Polytechnic State University at San Luis Obispo (Williams et al. 1995). In this batch study, carrot wash water (total dissolved solids of 2700 ppm and COD of 1000 ppm) was treated with a total dose of 3 mg ozone/L and bacteria levels reportedly were reduced by three logs. Unfortunately, the methodology was poorly described and the test data cannot be interpreted definitively.

Treatment and possible recycle of water used in washing poultry carcasses has been studied extensively and may be a commercial process. Chang and Sheldon (1989a) report that a combination of screening, diatomaceous earth filtration, and ozonation

yielded the highest quality of water, with total microbial loads (total coliforms, *E. coli* and *salmonellae)* reduced by 99.9% (levels of ozone in water were not measured in this study). In a second study, Chang and Sheldon found significant differences in measures of carcass quality including skin color, taste or shelf life, and the recycled water reconditioned with ozone produced carcasses of equal quality (including microbial counts) to fresh water (Chang and Sheldon, 1989b). In these studies, a 2.7-log reduction of total plate count was observed with the combined treatment train described above, including an ozone dose reported to be 30 mg/L (presumably based on applied dose not transferred ozone). A press release from the institution employing Chang and Sheldon suggests that the use of this process for a typical 240,000 broilers/day plant could result in savings of chiller water discharges by more than one-half and savings of more than $45,000 yr.

Applications of Gas Phase Ozone

Ozone in the gas phase is a powerful oxidant/disinfectant and it appears to have several advantages over other methods for odor control and surface disinfection. It is generally more effective for deactivation and control of microorganisms than alternatives; it can be generated on site and, therefore, a hazardous substance such as chlorine does not have to be transported or stored; it does not produce chlorinated byproducts of concern; and excess ozone can be decomposed to oxygen. It is a toxic gas, however, and care must be taken to protect workers from exposure.

As early as 1924, industrial applications of gaseous ozone in the food industry were described. Hartman (1924) states that *"in cold storage ozone is successfully used to prevent the growth of fungi"* (p. 724), and *"eggs have been carried at a relative humidity of 88 to 90 per cent and mold developments inhibited with the use of ozone"* (p. 725). Hartman summarizes by noting that ozon*e "has manifold applications in cold storage, and splendid results are being obtained in practice with this reagent every day"* (p.725).

In another early paper, Ewell (1950) summarized the use of ozone in food preservations, claiming that **"***the most important use of ozone is in egg rooms*" to reduce shrinkage and the contamination accompanying the storage air (p. 2)**.** In the same article, Ewell states that **"**ozone is unsurpassed for control of mold growth upon cheddar cheese during ripening**"** and that "ozone was, at least before the war, used extensively in meat rooms in Europe**".** This practice is apparently still followed, as evidenced by the description of the large-scale Braunwalder AG plant in Wöhlen, Switzerland by Imroth (1985).

In a text entitled "Anorganische Chemie" published in 1951, Wiberg noted that "ozone has been used technically, for example in air improvement and sterilization in theaters, schools, hospitals, cold rooms, meat packing houses, and breweries". In another text by Horvath, Bilitzky and Huttner (1985), it is noted that "utilization of ozone for increasing

the storage life of food, particularly if held at low temperatures, is believed to have started in 1909...in Cologne, (Germany)" (in meat storage rooms) and "*the use of ozone is increasing in several major cold-storage plants in Europe".* Horvath et al. (1985), also cite several published studies of the beneficial uses of ozone atmospheres in the storage of pears, cauliflower, potatoes (ozone entirely stopped the growth of *Phytophtora infestans)* and meat. In the latter case, while the germicidal effect of ozone is restricted to the surface of the meat, "the storage life of beef in a refrigerated state can be increased by 30 to 40 per cent if the beef is kept in an atmosphere of 10 to 20 mg (O_3)/ m^3.

Ozone gas is apparently being used now in connection with fruit storage in ships. The purposes are varied, depending on the fruit: for preventing early ripening, for destruction of off-tastes or odors, or preventing molds and decay (Ordrup Maskin-Import, Denmark area 1988).

In 1953, Kuprianoff summarized the advantages for treating fruits including berries, apples, pears, bananas, and oranges , in cold storage using gaseous ozone (Kuprianoff, 1953; circa 1953). Among the points made are the following:

- The effectiveness of ozone in preservation of fruits is affected by concentration of ozone, treatment time, relative humidity, and temperature.
- Ozone is a weaker bactericide than it is a fungicide.
- There appears to be a region of optimum concentration for effectiveness of ozone. Below a threshold (ca. 0.2 mg/m^3 air), bacterial growth may actually be encouraged, while at high concentrations fruit discoloration or skin damage may occur.
- Ozone acts on the surface of fruits so fruit must be packaged to allow free circulation of ozone-containing air during treatment.
- Ozone appears to be a cost-effective alternative for treatment of fruits in cold storage.

Recent Studies on the Extension of Storage Life of Stored Food Products.

Several recent controlled studies have confirmed the advantages of ozone/air treatment of food stuffs during storage and transport. Barth et al. (1995) evaluated ozone exposure for prevention of fungal decay on thornless blackberries. Fruit was harvested and stored for 12 days at 2°C in 0.0, 0.1 and 0.3 ppm ozone, then evaluated for fungal decay (*Botrytis cinerea),* anthocyanines, color and peroxidase activity. Ozone storage suppressed fungal development for 12 days, while 20% of control fruits showed decay. Treated fruit did not show observable injury or defects. Sarig et al. (1996) showed that ozone at low doses (0.1 mg/g of fruit) for 20 minutes, reduced the levels of fungi, yeasts and bacteria on grapes, but that higher doses caused some fruit damage. Naito and

associates in Japan have carried out similar experimental studies. In one study, this group demonstrated that the efficacy of ozone was highest when contact with cereal grains could be assured, temperature was low, and a sufficient ozone concentration (5 ppm) was used (Naito *et al.,* 1987). In a parallel study, Naito and Nanba (1987) showed that a small but insignificant decrease in thiamin occurred upon treatment of grains, peas, and whole spices with ozone. Naito et al. (1988) also showed that ozone treatment decreased *bacillus* and *micrococcus* on these products. For example, 10^0 to 10^3 fold decreases in the main microorganisms occurred with ozone concentration below 50 ppm and further decreased during storage, resulting in longer storage life. Similar improvements were found upon treatment of flour and Japanese raw noodles (Naito 1989) and no significant change in riboflavin occurred in the products. No change in lipid levels was observed when ozone was used to treat cereal grains, grain powder, peas and beans with 0.05 to 5 ppm ozone followed by storage at 10°C and 30°C for 60 days, but some effect on lipids was seen in bean jam powder and cereal grain powders at higher doses. Gabriel'yants' et al. (1980) showed that cheese stored with periodic ozonation at 5 -7 mg/m^3 for 4 hours at 2-3 day intervals showed no mold growth for 4 months. Controls showed mold growth as early as 1 month.

Gaseous treatment for disinfection of freshly laid, broiler hatching eggs was evaluated by Whistler et al. (1989a, 1989b) and is the subject of a recent Japanese patent (Hoshida.95a). The former papers indicate that ozone is a good disinfectant yet may adversely affect embryo development, resulting in lower hatchability (37.5% vs. 26.5% for controls). Unpublished results suggest that the loss of hatchability may have been an experimental artifact, e.g., the eggs were stored in water, which drowns chicken embryos (Rice, unpublished information).

Dondo et al. (1992) report that ozone treatment during refrigerated storage stabilized the surface bacterial count on beef and reduced that on fish. Kaess and Weidemann in Australia (1968) had carried out a similar study on beef muscle slices and showed a longer lag phase of *Thamnidium* and *Penicillium,* and small but significant inhibitory effects on *Pseudomonas and Candida scottii* after ozone treatment in the range of 0.15 to 5.0 mg/m^3 in air.

There appears to be a synergistic effect of gaseous ozone and carbon dioxide on the sterilization of food (Mitsuda et al, 1990). This is attributed to the quenching effect of carbon dioxide to the chain reaction of ozone degradation, and by the bacteriostatic effect of carbon dioxide gas.

In summary, several carefully controlled studies have confirmed earlier practical applications, showing that gaseous application of ozone extends the storage life by retarding the growth of microorganisms on the surface of fruits, vegetables, eggs and meat. The quality of most foods appears to be unaffected by ozone treatment at effective concentrations, but at high levels, usually above 50 ppm (mg/m^3) surface

damage and discoloration can occur, especially of fruits and meats. Care must be taken to protect workers from exposure to excessive levels of ozone.

Disinfection of indoor food processing facilities.

Ozone is an alternative to formaldehyde and other indoor fumigants for control of microorganisms in indoor food processing facilities. Holah et al. (1995) evaluated different methods for disinfection of air, including chemical fogging (unspecified chemical), UV light and ozone. Microbial survival was assessed using a variety of methods including settle plates, precipitation onto metal strips, impaction onto agar and impingement in a glass cyclone sampler. Ozone appeared to be both effective and reproducible in its effect on airborne microorganisms**.** Naito (1989) showed that ozone treatment inside a confectionery factory "remarkably inhibited" coliform bacteria, micrococcus and yeast growth in a cake manufacturing facility; coliforms were similarly inhibited in a pie factory but fungal levels were not affected. Similarly, Naito and Yamazawa (1989) showed that ozone treatment in a chikuwa factory reduced airborne microorganisms for 1-1.5 year and bacterial growth in ozone-treated chikuwa was "remarkably" inhibited. Storage life increased 7 days with a 5 ppm ozone treatment at 5°C and with a 50 ppm treatment at 10°C.

Greene et al. (1993) showed that ozonated and chlorinated water were equally effective in reducing bacterial counts by >99% in milk films on stainless steel plates previously exposed to incubated UHT-pasteurized milk inoculated with *Pseudomonas fluorescens* or *Akaligenes faecalis*. Cell densities were in the range of 10^4 to 10^6 cfu/cm^2.

Bibliography

Barth, M.M., C. Zhou, J. Mercier and F. A. Payne, **1995. "**Ozone storage effects on anthocyanin content and fungal growth in blackberries," *J. Food Sci.,* 60 (6), 1285-1288.

Blogoslawski, W.J. and P. O. Monasterio, **1982. "**Bacterial depuration of the Mexican scallop, *Argopecten circularisi*," *Ozone; Science & Engineering*, 4, 121-129.

Blogoslawski, W.J., C. Perez and P. Hitchens, **1993. "**Ozone treatment of sea water to control vibriosis in mariculture of penaeid shrimp, *Penaeus vannameii,"* Proc. International Symposium on Ozone-Oxidation Methods for Water and Wastewater Treatment, International Ozone Assoc., Wasser-Berlin, I.5.1-11.

Y.H. Chang and B.W. Sheldon, **1989. "**Application of ozone with physical wastewater treatments to recondition poultry process waters," *Poultry Sci.*, 68, 1078-1087.

Y.H. Chang and B.W. Sheldon, **1989. "**Effect of chilling broiler carcasses with reconditioned poultry prechiller water," *Poultry Sci.*, 68, 656-682.

Chen, H.-C., S.-O. Chang and S.-T. Ing, **1987. "**A study of the sterilization effect of ozone and its application for marine food processing," *J. Fish Soc. Taiwan* , 14(2), 79-89.

Chen, H.-C., S.-H. Huang, M.W. Moody and S.-T. Jiang, **1992. "**Bactericidal and mutagenic effects of ozone on shrimp (*Penaeus mondon)* meat," *J. Food Sci.*, 57(4), 923-927.

DeWitt, B.J. III, V. McCoid, B.L. Holt and D.K. Ellis, **1984. "** The potential use of ozonated ice for on board storage of Gulf of Mexico shrimp," *Proc. Ninth Annual Tropical and Subtropical Fisheries Technological Conference of the Americas,* Brownsville, TX, 269-279.

Dondo, A., C. Nachtman, L., Doglione, A. Rosso, A. Genetti, **1992.** "Foods: Their preservation by combined use of refrigeration and ozone," *Ingegneria Allimentare le Conserv Animali,* 8(3), 16, 18-19, 22-23, 25.

Ewell, A.W., **1950. "** Ozone and its applications in food preservation," *Refrigerating Engineering Application Data,* 50, 1-4.

Fauvel, Y. , **1963.** "The use of ozone as a sterilizing agent in sea water for the depuration of shellfish," *Intl. Comm. Sci. Explor. of the Mediterranean Ocean, Reports and Verbal Proc.*, 17(3), 701-706.

Fauvel, Y. , **1972.** "The use of ozone in sea water for cleansing shellfish," *Effluent and Water Treatment J.*, 12, 260-262.

Fauvel, Y. , **1977.** "The use of ozone in oyster farming and in associated industries." Presented at 3rd World Congress, International Ozone Association, Paris, France, May, 1977.

Fauvel, Y., G. Pons and J.-P. Légeron , **1979.** "Seawater ozonization and shellfish depuration," *Ozone: Sci. & Eng.*, 1, 147-165.

Gabriel'yants', M. A.; L. N. Teplova; T.I. Karpova; R. A. Kozlova; and G. F. Makarova, **1980.** "Storasge of hard rennet cheeses in cold stores with ozonation of air" (in Russian), *Xholodil'naya Tekhnika*, 51: 35-37.

Gorman, B. M., J.N. Sofos, J.B. Morgan, G. R. Schmidt and G. C. Smith, **1995**. "Evaluation of hand-trimming, various sanitizing agents, hot water spray-washing as decontamination interventions for beef brisket adipose tissue," *J. Food. Protection*, 58(8), 899-907.

Greene, A. K., B.K. Few and J.C. Serafini, **1993. "**A comparison of ozonation and chlorination for the disinfection of stainless steel surfaces," *J. Dairy Sci.*, 76, 3617-3620.

Haraguchi, T., U. Simizu and K. Aiso, **1969.** "Effect of ozone on preservation of fresh fish," *Bull Jap. Soc. Sci. Fisheries*, 35(9).

Hartman, F.E., **1924. "**The industrial applications of ozone," *Amer. Soc. Heating & Ventilating Engrs. J.*, 30, 711-727.

Horvath, M. , L. Bilitzky and J. Huttner, **1985. "**Ozone," *Akademiai Kiado, Budapest, Hungary*, pp. 305-330.

Hoshida, S., **1995**. "Ozone for preservation of poultry eggs," *JP 95,236,415 A2; JP 07236415; 12*, Sept. 1995.

Imroff, D., **1985., "**The Braunwalder AG large-scale meat processing plant in Wohlen, Switzerland. Ripening under controlled conditions with air sterilization," *Fleischerei*, 36(38), 589-590.

Kaess, G. and J.F. Weidemann, **1968. "**Ozone treatment of chilled beef," *J. Food Technol.*, 3, 325-334.

Kondo, F.K., Utoh, M. Rostamibashman, **1989**. "Sterilizing effect of ozone water and ozone ice on various microorganisms," *Bull. Fac. Agriculture, Miyazaki Univ.*, 36(1), 93-98.

Kuprianoff, J., **1953.** "The use of ozone for the cold storage of fruit," *Z. Kaltentechnik*, volume 10 (translation).

Kuprianoff, J., **circa 1953.** "The use of ozone in cold storage of fruit," *Institut International du Froid, 177, Blvd. Malesherbes, Paris, France*.

Lee, J.S. and D .E. Kramer, **1984. "**Effectiveness of ozone-treated wash water and ice on keeping quality and stability of sockeye salmon," *Report to Alaska See Grant College Program and Alaska Department of Environmental Conservation,* Fishery Industrial Technology Center, University of Alaska, Kodiak, AL.

Mitsuda, H., H. Ominami and A. Yamamoto, **1990**. "Synergistic effect of ozone and carbon dioxide gases for sterilizing food," *Proc. Japan Acad. Sci., 66, Ser. B, 68-72.*

Naito, S., Y. Okada, and T. Sakai ,**1987. "**Studies on Utilization of Ozone in Food Preservation, Part III., , Microbiocidal Properties of Ozone on Cereal Grains, Cereal Grain Powders, Peas, Beans, and Whole Spices," *Nippon Shokukia Kogyo Gakkaishi*,34(12):788-793.

Naito, S., and Y. Nanba, **1987**. "Studies on Utilization of Ozone in Food Preservation Part IV. The Effect of Ozone Treatment on Thiamine and Riboflavin Contents of Cereal Grains, Cereal Grain Powders, Legumes and Whole Spices," *Nippon Shokuhin Kogyo Gakkaishi,* 34(12):794-800.

Ong, K. C., J.N. Cash, M.J. Zabik, M. Siddiq and A. L. Jones, **1996. "**Chlorine and ozone washes for pesticide removal from apples and processed apple sauce," *Food Chemistry,* 55(2), 153-160.

Ordrup Maskin-Import, Technical literature, **circa 1988.**, Skovlytoften 10, Denmark.

Salmon, J. and J. Le Gall, **1936**."Application of ozone for maintaining the freshness and prolonging the preservation time of fresh fish," *Revue Général du Froid*, 317-322.

Salmon, J. , J. Le Gall and A. Salmon, **1937a**. "Preliminary note on some experiments of purifying some edible marine molluscs by ozonized seawater," *Annales d'hygiéne publique, industrielle, et sociale,* 15, 44-50.

Salmon, J., A. Salmon and J. Le Gall, **1937b.** "A depuration station for shellfish using ozonized seawater," *Annales d'hygiéne publique, industrielle, et sociale*, 15, 581-583.

Sarig, P., T. Zahavi, Y. Zutkhi, S. Yannai, N. Lisker and R. Ben-Arie, **1996.** "Ozone for control of post-harvest decay of table grapes caused by *Rhizopus stolonifer*," *J. Physiol. and Molecular Plant Pathology*, 48(6), 403-415.

Spotts, R.A. and L. A. Cervantes, **1992. "**Effect of ozonated water on postharvest pathogens of pear in laboratory and packinghouse tests," *Plant Disease* , 76(3), 256-259.

Smith, G. C., J. N. Sofos, J. B. Morgan and J. O. Reagen. **1995.** "Carcass washing and decontamination." IFT Annual Meeting: *Abstracts*, June 3-7, Paper No. 62-5, , p.177.

Violle, H., **1929. "**The sterilization of seawater with ozone: application of this method for purification of contaminated shellfish," *Rev. Hygiéne et de Médecine Préventive*, 51, 42-49.

Whistler, P E. and B. W. Sheldon, **1989**. "Biocidal activity of ozone *versus* formaldehyde against poultry pathogens inoculated in a prototype setter," *Poultry Sci.,* 68, 1068-1073.

Whistler, P. E. and B. W. Sheldon, **1989.** "Bactericidal activity, eggshell conductance, and hatchability effects of ozone *versus* formaldehyde disinfection," *Poultry Sci.,* 68, 1074-1077.

Wiberg, E., **1951.** *Anorganische Chemie*, Walter de Gruyter & Co., Berlin, p.175.

Williams, D.W., J. Montecalvo, D. Earls and E. Mueller, **1995. "**Effect of ozone upon various vegetable washwater parameters," Report from Calif. Polytechnic State University at San Luis Obispo.

4

SAFETY ISSUES-TOXICOLOGY

Gordon W. Newell, Ph. D.

Ozone is one of the most widely studied chemicals, principally because of its high reactivity with biological systems. In some ways it could be considered the chemical Dr. Jeckel and Mr. Hyde: at stratospheric altitudes the ozone layer provides us with protection against solar UV irradiation, while at ground levels and in congested urban areas ozone is the major oxidant of photochemical smog. Acute ozone exposures in humans cause decrements in pulmonary function, induce inflammation, and alter ventilation capacity (Kleeberger, 1995). On the other hand, there is a long history, dating back to the nineteenth century, of the successful use of ozone in producing potable water both in Europe and the United States (Langlais et al., 1991, pp.1-8). In this century, ozone has been studied extensively for its potential as an agent to control the ripening of fruits and vegetables, as well as to extend the storage time of fish and meat products.

In Japan, ozone is included in a "List of Additives Already in Existence," which was developed in 1995, and is equivalent to the United States GRAS listings, wherein there is no restriction on the use of the identified components (Japan 1995,1995a, 1996)

Likewise, the Australian food processing standards include the use of ozone as an appropriate food processing aid. The maximum permitted residue for a processing aid in a food is not specified, which means that the residue of the processing aid should be at the lowest practicable level which achieves the desired technological function (Australian Food Standards Code,1996)

The most recent French publication of ozone regulations (France, 1995) specifically approves the use of ozone in aqueous solution for bleaching of fish pulp and appears to represent an attempt to make the regulations for consumption and purity consistent with the requirements of other member countries of the European Economic Community

The next several paragraphs include reviews and summaries of toxicological studies conducted with ozone. Studies with microorganisms and cell cultures were conducted by bubbling ozone through the liquid cultures or by passing the ozone vapor into culture bottles at known concentrations and for specified times. Animal studies were

by inhalation exposures. The investigations focus on dose-related responses, and information from such studies aid in understanding mechanism(s) of action. However, the issue under consideration is the safety of foods treated with ozone; that is, does the interaction of ozone with constituents of food result in products that may be harmful to consumers?

The potential genotoxicity of ozone has been evaluated in a number of *in vivo* and *in vitro* systems, but the findings are not consistent. In a comprehensive and critical review of these investigations, Victorin (1992) offers probable reasons for many of the inconsistencies, including variable treatment conditions, such as different concentrations, different times of exposures, and a lack of test system control. Several illustrations follow: Hamelin and Chung (1989) reported DNA strand breaks when ozone at 0.5 ppm was bubbled through *E. coli* cell suspensions for 4.5 hours, but no strand breaks were reported when De Mik and De Groot (1978) exposed aerosolized *E. coli* to 0.04 ppm ozone for 45 minutes. Gooch et al. (1976) reported chromatid-type aberrations in human leukocytes when ozone was bubbled through a suspension of cells in Hanks balanced salt solution; but, no aberrations occurred when leukocytes were put into ozone-saturated phosphate buffered saline for either 12 or 36 hours. Tice et al. (1978) exposed Chinese hamsters to 0.43 ppm ozone for 30 minutes. Examination of the lymphocytes for chromosome-type aberrations produced both positive and negative results. The same types of inconsistencies were reported by Merz et al. (1975) who exposed humans to 0.5 ppm ozone for periods ranging from 30 minutes to 10 hours. Because of the small sample size, a conclusion on the cytogenetic effects of ozone in human lymphocytes cannot be drawn.

A study of the mutagenic potential of amino acids and saccharides treated with ozone (an ozone stream of 110-120 ppm for 1-5 hour periods) resulted in no mutagenic products from the 18 amino acids studied nor of the 10 freeze-dried saccharides (Naitoh, 1992).

The carcinogenicity of ozone has been addressed over the past 30 years in experiments using various strains of mice, but almost all of these studies lacked definitive parameters of design or in the reporting. Stockinger (1965) reported the induction of lung tumors (adenomas) in mice exposed daily to 1 ppm ozone for fifteen months. Since no further information was provided, this study is of limited value. In two studies which extended for six months, A/J mice were exposed intermittently to either 0.31 or 0.5 ppm ozone, (Hassett et al., 1985). Lung adenomas were reported in the ozone-treated mice, but the incidence was statistically significant only in the second experiment. In another study with A/J mice, Last et al. (1987) reported the development of lung adenomas after 4.5 months of ozone exposure to 0.8 ppm, but not at 0.4 ppm. However, Swiss Webster-strain mice were resistant to the development of lung tumors when exposed to either 0.4 ppm or 0.8 ppm of ozone for 18 weeks (Last et al., 1987). A weight of analyses suggests that ozone is only a weak tumorigen, and not a carcinogen.

Since the following investigations were designed to be comprehensive studies for evaluating the toxicological parameters of ozone, this commentary is more detailed than for the previously cited studies. In the early 1990s, at the request of the State of California and the Health Effects Institute, the National Toxicology Program, a segment of the National Institutes of Health and the Department of Health and Human Services, agreed to undertake a comprehensive investigation of the long-term effects of ozone on the intact mammalian system (NTP, 1995). Preliminary 4-week ozone exposures to male and female F344/N rats and B6C3F mice at inhalation concentrations of 0, 0.5 and 1.0 ppm were conducted for 6 hours per day for 20 days. All animals survived the treatment regimen, showing only an infiltration of granulocytes and macrophages in the alveolar ducts.

Using the preliminary findings, two-year studies with mice and rats were designed to include doses of the EPA standard of 0.12 ppm of ozone, a 1.0 ppm level believed to be compatible with long-term survival, and an intermediate level of 0.5 ppm, plus controls of 0.0 ppm ozone. Groups of 50 male and 50 female mice and rats (mouse and rat species as above) were exposed by inhalation for six hours per day, 5 days per week, for 125 weeks (for rats) and 130 weeks (for mice).

At the doses used, ozone had no effect on the survival of either mice or rats, and only minimal effects on weight gain. Also, the investigators reported that the biochemical and structural changes noted in the lungs of rats repeatedly exposed to ozone for 20 months did not significantly affect pulmonary function.

Ozone was non-carcinogenic to the F344/N rat. Although two female rats developed pulmonary neoplasms in the 0.5 ppm ozone group, tumors of this type did not occur at lower or higher treatments, nor in the control. Thus, this singular event demonstrates a lack of a dose response. Non-dose-related findings occurred in the male rats, prompting the authors to comment that these scattered incidences argue against ozone having even a marginal effect on the incidence of pulmonary neoplasms in these rats. Another study, conducted with Wistar-strain rats, used ozone alone or in combination with nitrogen dioxide and/or sulfuric acid aerosols (Ichinose and Sagai, 1992); none of these treatments stimulated the development of pulmonary tumors.

In designing this program, it was recognized that ozone, while not acting as a direct carcinogen, might be able to promote the carcinogenic process or act as a cocarcinogen. Therefore, an additional experiment was conducted in which male rats were exposed to ozone (0.5 ppm), plus a known pulmonary carcinogen, NNK: 4-(N-methyl-N-nitrosamino)-1-(3-pyridyl)-1-butanone, which was injected subcutaneously three times per week in trioctanoin for 20 weeks, with the experiment lasting for 105 weeks. Although rats treated with NNK developed pulmonary adenomas and carcinomas, the addition of ozone to the experimental regimen did not increase the incidence of the lung tumors (NTP 1995).

Ozone increased the incidence of pulmonary neoplasms in the B6C3F1 mouse, a strain known to be susceptible to the development of lung tumors. On the other hand, Last (1987) found no increase in the incidence of pulmonary neoplasms in Swiss Webster mice chronically exposed to ozone. This pulmonary response of mice to ozone appears to be strain-specific, rather than a generalized carcinogenicity characteristic of ozone.

As mentioned earlier, consideration must be given to the potential occurrence of toxic reaction products when foods are treated with ozone. This issue was raised over 20 years ago during a symposium on the gaseous sterilization of foods (Gammon and Kereluk, 1973), wherein the toxic effects of residuals as well as ways and means of rapidly eliminating such residuals from the foodstuffs were discussed. More recently, Pryor et al. (1995a,b; private communication) investigated the mechanisms of ozone toxicity in the lung. Ozone is so reactive that it is entirely consumed as it passes through the first layer of tissue it contacts at the lung/air interface. It is hypothesized that biochemical reactions influence the development of lipid ozonation products, as a result of the interaction of ozone and unsaturated fatty acids in the pulmonary cell biolayers. Some of these oxidation products have been isolated and synthesized. Specifically, lipid oxidation products of unsaturated fatty acids in mammalian tissues are finite in number, have predictable structures and are small, stable molecules (Pryor et al., 1995b). The significance of single strand breaks in human lung tissue following ozonation of arachadonic acid is unclear. Increased single strand breaks are presumably an indicator of the carcinogenic/mutagenic potential of a substance. But, ozone exposure of rats and several strains of mice did not produce carcinogenic responses (NTP, 1995); no mutagenic responses were observed when various amino acids and saccharides were treated with ozone (Naitoh, 1992).

There is limited information regarding the safety of foodstuffs treated with ozone. Two carefully designed and recent papers, however, discuss the effects of feeding ozonated casein to rats (Kasei et al., 1993, 1994). Casein was dissolved in 8 M urea, and then 0.3% ozone in an oxygen stream was bubbled into the solution at a rate of 100 liters/hr for 20 hours; a severe treatment regimen. Ozonated casein was obtained after lyophilization of the dialyzed solution. Chemical analyses showed significant losses of cystine, methionine, tyrosine, tryptophane, phenylalanine and histidine in the ozonized caseins; the concentration of each amino acid in the treated and untreated caseins was equalized by the addition of a suitable amount of the free amino acid. Groups of six rats were fed the experimental diets for a two-week period, with the caseins at 8%; a fourth group received 4% egg white and was included for the measurement of biological value and true digestibility of each experimental diet.

Growth and food intake was essentially the same for the ozonated casein groups and slightly less than the untreated casein group, but the difference was not significant. The biological value of the ozonated casein diet was not inferior to the native casein diet, but the true digestibility of the ozonated casein diet was significantly less than that of the native casein diet. Kidney, cecum and liver weights of rats fed the ozonated caseins

were significantly greater than those fed the native casein. No significant differences in weight of other organs were observed. The enlarged cecum was considered to be caused by the lower digestibility of ozonized casein--because the cecums of rats fed casein ozonated after predigestion with pepsin, were smaller compared with those fed ozonated casein. The cause of kidney enlargement was not determined. A part of the liver enlargement of the ozonated casein-fed group was due to the accumulation of triglyceride. Effects of amino acids on fat deposition in the liver of rats fed a low protein diet are attributable to amino acid imbalances. Others have shown that an 8% casein diet with 0.3% methionine develop fatty livers as the plasma level of threonine and serine decreases. Liver fat accumulation is prevented by the addition of threonine.

The literature also suggests that the oxidation products formed when foodstuffs are treated with ozone are similar to those formed when water is treated with ozone. Although the data are somewhat limited, the available information does not suggest significant health problems.

Results to support this position include:

1. Repeated, long term inhalation studies with animals show ozone is not a carcinogen (NTP, 1995).

2. No mutagenic products were detected after 18 different amino acids and 10 freeze-dried saccharides were treated for 1-5 hours with ozone (Naitoh, 1992).

3. By-products of the reaction of ozone with unsaturated fatty acids are primarily aldehydes, ketones and hydrogen peroxide (Kozumbo et al., 1996).

4. The biological value of ozonated casein was shown to be comparable to untreated casein, although the digestibility of an ozonated diet was less than that of a native casein diet. Adverse metabolic effects in rats fed ozonated casein was shown to be due to a loss of certain amino acids, and not from an accumulation of toxic components.

5. In Japan and Australia there are no quantitative restrictions on the use of ozone as a food processing agent. The most recent publication of French Standards appears to represent an attempt to make the regulations consistent with the requirement of other member countries of the European Economic Community.

Bibliography

Australian Food Standards Code, **1946.** " STANDARD A16-Processing Aids; Amendment 29 to Foods Section, Table II, Group II." Published in *Commonwealth of Australia Gazette,* pp. 15-40, April 4.

De Mik, G.; De Groot, I. ,**1978**. "Breaks induced in the deoxyribonucleic acid of aerosolized *Escherichia coli* by ozonized hexene." *Appl. Environ. Microbiol*. 35, 6-10.

France, **1995**. "Decrees of 24 January and 23 January 1995 relative to various technological additives in human foods," *Journal Officiel de la Republique Francaise 4 Mars, **1995.*** P. 3457.

Gammon, R.; Kereluk, K., **1973**. "Gaseous sterilization of food." Am. Inst. Chem. Engrs. Symp. Series 69 (132), 91-93.

Gooch, P.C.; Creasia, D. A.; Brewen, J.G., **1976**."The cytogenetic effects of ozone: inhalation and in vitro exposures." *Environ.. Res* 12, 188-195.

Hamelin, C.; Chung, Y.S.,**1989**. "Repair of ozone-induced DNA lesions in *Escherichia coli* B cells." *Mut. Res*. 214, 253-255.

Hassett, C.; Mustafa, W.F.; Coulson, W.F.; Elashoff, R.M., **1985**. "Murine lung carcinogenesis following exposure to ambient ozone concentrations." *J. Natl. Inst*. 75, 771-777.

Ichinose, T.; Sagai, M., **1992**. "Combined exposure to nitrogen dioxide, ozone and sulfuric acid-aerosol and lung tumor formation in rats." *Toxicology* 74, 173-184.

Japan, **1995**. Prime Minister of Japan. "Law # 101: Proclamation of the change of May 24, of a portion of Food Hygiene Law and Nutrition Improvement Law." *Official Report* # 165, Printing Office of Treasury Ministry, May 24.

Japan, **1995a**, Ministry of Welfare. "Notification # 160: List of Additives Already in Existence. *Official Report* # 151," Printing Office of Treasury Ministry, August 10 (extra).

Japan, **1996**, Ministry of Welfare. "Notification # 120: List of Additives Already in Existence." *Official Report # 90,* Printing Office of Treasury Ministry, April 16 (extra).

Kasai, T., Iwashita, A., Kiriyma, S., **1993**. "Growth is Compromised in Rats Fed Ozone-Treated Casein." *J. Nutr*. 123, 893-899.

Kasai, T., Sakamaki, T., Kiriyama, S., **1994**. "Modified Process for Preparation of Ozonated Casein and Nutritional Evaluation of the Product with Rats." Biosci. Biotech. Biochem. 58, 451-454.

Kleeberger, S. R., **1995**. "Genetic susceptibility to ozone exposure." *Toxicol. Ltr*., 82/83, 295-300.

Kozumbo, W.J., Hanley, N. M., Agarwal, S., Thomas, M.J., Madden, M.C., **1996**. "Products of Ozonized Arachidonic Acid Potentiate the Formation of DNA Single Strand Breaks in Cultured Human Lung Cells." *Environ. Mol. Mutagenesis*, 27, 185-195.

Langlais, B.; Reckhow, D. A.; Brink D.B., eds., **1991. "**Ozone in Water Treatment-Application and Engineering." Chelsea, MI. Lewis Publishers, Inc., pp. 1-8.

Last, J. A.; Warren, D.L.; Pecquet-Goad, E.; Witschi, H.P. ,**1987**. "Modification by ozone of lung tumor development in mice." *J. Nat. Cancer Inst*. 78, 149-154.

Merz, T.; Bender, M. A.; Kerr, H. D.; Kulie, T.J. ,**1975**. "Observations of aberrations in chromosomes of lymphocytes from human subjects exposed to ozone at a concentration of 0.5 ppm for 6 and 10 hours." *Mut. Res*. 31, 299-302.

Naitoh, Shigezo,**1992**. "Studies on the application of ozone in food processing. Mutagenicity of ozone-treated aminio acids and saccharides." *J. Antibact. Antifung. Agents*. 20, 265-372.

NTP ,**1995**. "Toxicology and carcinogenesis: studies of ozone and ozone/NNK." United States National Toxicology Program. NIH publication No. 95-3371.

Pryor, W. A.; Squadrito, G. L.; Friedman, M., **1995a**. "The cascade mechanism to explain ozone toxicity: the role of lipid oxidation products." *Free Rad. Biol. Med*. 19, 935-941.

Pryor, W. A., Squadrito, G. L., Friedman, M. ,**1995b**. "A new mechanism for the toxicity of ozone." *Tox. Ltrs*. 82/83, 287-293.

Pryor, W. A.; (Personal Communication) ,**1996**.

Stockinger, H.E. ,**1965**. "Ozone toxicology." *Arch. Environ. Health* 10, 719-731.

Tice, R. R.; Bender, M .A.; Ivett, J.L.; Drew, R.T.,**1978**. "Cytogenetic effects of inhaled ozone." *Mut. Res*. 58, 293-304.

Victorin, K. ,**1992**. "Review of genotoxicity of ozone." *Mut. Res*. 277, 221-238.

5

NUTRIENT IMPACT

John W. Erdman, Jr.

Introduction

Foods are processed for several purposes: to preserve the food and to extend its shelf-life, to increase its digestibility , to improve its palatability and texture, to prepare it for serving, to remove inedible parts, to destroy antinutritional factors, to create new types of foods and to destroy toxins and eliminate microorganisms. Of foremost concern is the safety of the food, as consumed. Although most food preservation techniques decrease the overall nutrient content of the food to some degree, this is a necessary price to pay for safety. Thus choice of the most appropriate food processing techniques is always a question of balance between extent of preservation and safety of the food and the nutrient retention following processing (Erdman and Poneros-Schneier, 1994).

There are three major causes of food spoilage: chemical changes, enzymatic changes and, most relevant to an application of ozone, microbiological spoilage. The effectiveness of ozone in reducing levels of bacteria, molds, yeast, etc., was established earlier in this report (Efficacy of Ozone in Food Processing). The traditional food preservation methods utilized to reduce microbiological load include thermal processing, alteration of pH, use of chemical preservatives, use of microwaves and ionizing radiation, removal of water, or a combination of these techniques. Essentially all of these techniques will reduce, to a varied degree, the nutrient content of the preserved food.

Most nutrients are oxidized by excess heat, and some are adversely affected by changes in pH, or by light, oxygen or by selected chemical preservatives. The other major mechanism of nutrient loss is leaching out of foods by excess water use. The most labile of the nutrients in foods are some of the water soluble vitamins whose chemical structures are sensitive to heat and chemical changes and are, as well, quite water soluble and can be easily leached into the surrounding fluid. Certain amino acids and fatty acids can be oxidized during food processing, but not usually to the extent of vitamins.

Ozone is a strong oxidant and thus would be expected to cause alterations in nutrient levels in foods if high concentrations of this material are used for extended periods.

However, ozone does not penetrate deeply into foods (Kuprianoff, 1953) and any negative impact on nutrient content is limited to nutrients on the surface of the food.

Below is a review of the published literature on the effects of ozone on each major nutrient class. It will become clear that there is not a great deal of published literature on the subject. It appears that under properly-controlled preservation conditions, ozone causes only minor losses of nutrient content, lower than some other processes commonly in use.

Vitamins

The vitamins that are most labile in oxidizing conditions include vitamin C, vitamin B1 (thiamin), folate and the carotenoids. Often vitamin C and thiamin are utilized as indicator nutrients when monitoring the effects of food processing techniques upon stability of nutrients. If these compounds are retained to a high degree then it is assumed that others are as well.

Two Japanese papers have evaluated the effects of ozone treatment on the thiamin and riboflavin (vitamin B2, another water soluble vitamin with more stability to heat than thiamin but less stability to light) retention in cereal and bakery product, peas, beans and whole spices. Naito and Nanba (1987) treated 24 different kinds of foods, including cereal grains, cereal grain powders, peas, beans, and whole spices with 0.5 to ca 50 ppm ozone at 10° C for 1 hour. Riboflavin proved to be very stable during treatment with over 90% retention of Vitamin B2 in all food samples, even with treatments of 50 ppm ozone. Thiamin decomposition was detected in some food samples of flours and spices treated with 50 ppm ozone. Losses amounted to up to 40% in products with high surface areas but minimal losses (~ 10%) were seen in whole grain and bean products. Naito et al. (1989) also treated wheat flour with 0.5-50 ppm ozone for 6 hours to control airborne microorganisms prior to the production of Japanese noodles and again found no changes in riboflavin. The shelflife of the produce was substantially increased, although some thiamin content was lost.

Recently, Henry and coworkers (1996) studied the degradation kinetics of the carotenoids, beta-carotene and lycopene *in vitro* after exposure to a continuous flow of oxygenated or ozonated water. Each carotenoid was adsorbed onto a solid surface and ultra-filtered water saturated with either oxygen or ozone was flowed over the surface at ambient temperature. As expected, ozone was a stronger oxidant than oxygen. Approximately 90% of the color of lycopene and beta-carotene were lost after 1 and 7 hours, respectively, with ozone, and in 2 and 7 hours for oxygen. Thus, lycopene, the primary red pigment in tomatoes, is more susceptible than is beta-carotene.

When potatoes were stored under ozone-containing environment, there was a 1.2-fold higher content of vitamin C than the control sample (Kolodyanznaya and Suponina,

1975). This change probably reflects an effect of ozone on metabolism in the potatoes, as total sugars also decreased by 1.3-1.5 fold with a 3-6% increase in starch content. The mechanism of these changes most likely is due to ozone's known oxidizing effects on ethylene (a plant hormone that increases ripening) with an end result of slowing the ripening process.

Proteins

It is quite clear from studies of ozonolysis of water for drinking or for food processing that extensive use of this oxidant will chemically destroy a variety of amino acids (Rice and Gomez-Taylor, 1986). Similarly, La Lacheur and Glaze (1996) have shown that oxidation of serine in water produces a set of carbonyl^{-} and carboxylate^{-} containing by-products that reflect both O_3 and OH^{-} chemistry (see Executive Summary) Oxidativie decarboxylation and nitrate formation is the preferred route of reaction of serine with O_3 while ammonia formation indicates OH^{-} radical chemistry. The reaction sequences of ozone with glycine, alanine, and phenylalanine, for example, have been delineated, but the progress of the reactions is the same as for chlorine, another strong oxidant used to purify water.

Kasai et al. (l994) used ozonolysis processing to prepare an ozonated casein. This harsh treatment completely destroyed all aromatic amino acids, except for a few of the phenylalanine residues, and reduced the true digestibility of the casein. Naitoh (l992) evaluated the effects of high levels of ozone (110-120 ppm) on the ozonation of amino acids in aqueous solution and found that the most labile amino acids were tryptophane, tyrosine, phenylalanine and methionine. The metabolic products produced during this process were not found to be mutagenic, whether or not the pure amino acids or mixtures of amino acids and glucose were ozonated.

In all of the above studies, extremely high levels of ozone were utilized. There is no evidence that exposure of foods to levels of ozone typically suggested for food preservation will cause any destruction of amino acid residues or reduction of protein quality.

Lipids

Naitoh (1989) treated cereal grain powders, peas, beans, pulse products and cereal grains with 0.05 to ca 50 ppm ozone and found that up to 5 ppm ozone oxidation of lipids rarely occurred, while at higher ozone levels (50 ppm and higher), considerable lipid oxidation was noted. Gorman *et al.* (1995) studied the effects of several types of disinfecting treatments, including 0.5 % ozonated water on the TBA content of beef following 29 days storage of the meat at 4 C. Sheldon and Brown (1986) compared the use of ozonated poultry carcasses with chilled water carcasses and reported higher TBA numbers in some tissues with ozone but not with others. Sensory panels could not

detect differences between treatment of the broiler meat. Watanabe et al. (1994) used ozone (0, 0.03, and 0.1 ppm) during cultivation of nameko mushrooms and found that the ozone treatment increased palmitoleic acid contents and decreased the linoleic acid and PUFA/SAT FA ratios.

Ozone is known to react rapidly with unsaturated organic compounds (Rice, 1982); thus it would not be a surprise to find that at higher levels of exposure to ozone, some oxidation of PUFA and increase in peroxidation of fat had occurred. However, at usual levels of treatment, no significant effects are expected to occur.

Minerals

Langlais (1982) demonstrated that ozone could be used to oxidize Fe^{+2} and Mn^{+2} in water to be used for soft drinks. It is not likely that ozone at levels usually used to preserve foods that minerals will be substantially affected.

Conclusions

Ozone is a strong oxidant and has the potential to reduce the content of labile nutrients in a concentration- and time-dependent manner. Because ozone only affects the surface of foods and the concentrations of ozone expected to be used for food preservation are low, it is expected that ozone will have minor impact on the nutrients in foods, lower than some other processes commonly in use for food preservation. Foods with high surface areas such as flours and leafy vegetables would be most affected by ozone. The nutrients that are most labile to other oxidizing food preservation processes, such as vitamin C and thiamin, will also be most affected by ozone.

Bibliography

Erdman, J.W., Jr. and Poneros-Schneier, A.,**1994**. "Factors affecting nutritive value in processed foods." In: *Modern Nutrition in Health and Disease, 8th edition*. M.E. Shils, J. A. Olson, M. Shike, editors. Lea and Febiger, Philadelphia, PA. pp. 1569-1578.

Gorman, B.M., Kochevar, S. L., Sofus, J.N., Morgan, J.G., Schmidt, G.R. and G.C. Smith, **1995**. "Shelflife of beef tissue following spray-washing with chemical solutions and 35C or 74C water."(Abstract) *IFT Annual Meeting 1995*, p. 140.

Henry, L., Jaren, M., Catignani, G. and S. Schwartz,**1996**. "The effects of ozone and oxygen exposure on the degradation kinetics of β-carotene and lycopene." *Presented at the 11th International Symposium on Carotenoids*. *Leiden, The Netherlands*. August 18-23. Abstract 42).

Kasai, T., Sakamaki, T. and S. Kiriyama, **1994**. "Modified process for preparation of ozonated casein and nutritional evaluation of the product with rats." *Biosci., Biotech., Biochem*. 58(3):451-454.

Kolodyaznaya, V.S. and T. A. Suponina, **1975**. "Storage of foods using ozone." *Kholodil'naya Tekhnika* 6:39-41.

Kuprianoff, J., **1953**. "The use of ozone for the cold storage of fruit." *Z. Kaltentechnik*. 10:1-4.

La Lacheur and W. H. Glaze, **1996.** *Environmental Sci. and Technology*. 30: 1072-1080.

Langlais, B.,**1982**. "Study Session -- Malt house/brewery production of unfermented soft drinks." Presented to *Agence pour la Corporation Industrielle et Économique, Paris, France.* March 8 - April 8.

Naito, S. and Y. Nanba, **1987**. "Studies on utilization of ozone in food processing. Part IV. The effect of ozone treatment on thiamine and riboflavin contents of cereal grains, cereal grain powders, legumes and whole spices." *Nippon Skokuhin Kogyo Gakkaishi*. 34(12):794-800.

Naito, S., Sawada, Y. and N. Yamaguchi, **1989**. "Studies on utilization of ozone in food preservation. Effects of ozone treatment on storage of packaged Namamen Japanese raw noodle." *J. Antibacterial and Antifungal Agents, Japan.* 17(11):517-526.

Naitoh, S., **1989**. "The influence of ozone treatment on lipids contained in cereal grains, cereal grain powders, peas, beans and pulse products (studies on utilization of ozone for food preservation, Part VI)." *J. Japanese Soc. of Food Science and Tech.* 36(11):878-883.

Naitoh, S., **1992**. "Studies on the application of ozone in food preservation mutagenicity of ozone-treated amino acids and saccharides." *J. Antibact. Antifung. Agents* 20(7):365-372.

Rice, R.G. and M. Gomez-Taylor, **1986**. "Occurrence of by-products of strong oxidants reacting with drinking water contaminants - scope of the problem." *Environmental Health Perspectives* 69:31-44.

Rice, R.G., J.W. Farquhar and L.J. Bollyky, **1982**. "Review of the applications of ozone for increasing storage times of perishable foods." *Ozone: Science and Engineering* 4:147-163.

6

SUMMARY OPINION OF THE EXPERT PANEL

Joseph F. Borzelleca, Ph. D.

The Evaluation of the Health Aspects of Ozone as a Sanitizing Agent for Foods

An Expert Scientific Panel (Panel) was assembled by R & D Enterprises at the request of The Electric Power Research Institute (EPRI) to evaluate the available information on the efficacy and safety of ozone for use as a disinfectant or sanitizer for foods and in food processing applications, and to determine the GRAS status of ozone for these purposes. A comprehensive search of the scientific literature was conducted including TOXLINE, MEDLINE (the National Library of Medicine), EMBASE (Elsevier Science B. V.'s Excerpta Medica database), and RTECS (the Registry of Toxic Effects of Chemical Substances) and was made available to the members of the Expert Panel. All articles requested were provided to the Panel. In addition, the Panel also used reference books, review articles, and other information deemed appropriate. Data from unpublished studies also were considered. The knowledge and experience of the Panel were critical in evaluating the information available.

In the Food, Drug, and Cosmetic Act (21 U.S.C. section 321), three classes of food additives are mentioned: food additives—that require premarketing approval; GRAS substances—that do not require premarketing approval; and prior sanctioned additives-that were granted premarketing approval (but prior sanctioned is no longer a viable category). GRAS status may be based on the general recognition of safety determined by experts who are qualified by scientific training and experience to properly evaluate scientific data that is published and is publicly available to determine the safety of a food ingredient (21 C.F.R. sections 170.3 and 170.30). Unpublished data may be used to support credible published information. The judgment of the Panel should consider anticipated patterns of consumption ('exposure data') including potentially sensitive segments of the population and heavy consumers (90th percentile of eaters) and cumulative effects. Appropriate safety or uncertainty factors may be considered in the extrapolation of data from studies in animals to humans.

The Panel is eminently qualified by training and experience in relevant disciplines including food science, food technology, nutrition, toxicology, and ozone chemistry to

render such an opinion on the GRAS status of ozone as a sterilant for foods. The *curricula vitae* of the Panel appear as Appendix 1.

The Panel was aware of the above regulations and conducted its evaluation accordingly; that is, it relied primarily on credible published data as well as supporting evidence from unpublished studies. The members of the Panel independently reviewed the results of a comprehensive search of the scientific literature as noted above, other materials provided to them, and other information deemed appropriate. The Expert Panel consulted by conference calls to review their independent findings and convened in Washington, DC on several occasions. During the review, the Panel considered the history of ozone use, the methods of preparation, the chemical and physical properties, current and proposed applications, effectiveness as a sanitizing agent, biological reactivity, and safety.

There are many potential applications for ozone in the food industry due to its strong oxidizing and disinfecting properties. These applications range from increasing the yield of certain foods while growing (e.g., mushroom cultivation), to storage and transportation of fresh meats, to treatment of water used for washing foods, food products, and the packages in which they are stored, to treatment of wastewaters from food processing facilities, to control of molds and spores in high moisture facilities (e.g., breweries and wineries, particularly in cellars). Some products, such as cheeses, can be exposed to ozone-containing atmospheres just prior to packaging, thus extending the shelf-life of the cheeses by lowering the microbial population on the surface of the cheeses. In all applications in which ozone comes into contact with foods, it is essential to use enough ozone to accomplish the intended purpose (e.g. microbiological control, deodorizing, elimination of spores) without degrading the product itself (i.e., damaging the organoleptic properties) due to oxidation by ozone.

The effectiveness of ozone as a disinfecting and sanitizing agent has been well established and it may be more effective than chlorine or chlorine dioxide in certain situations. In treating surface water for potable use , the U.S. Environmental protection Agency has confirmed ozone as the most effective primary disinfectant available. Because of the short half-life of ozone in water used for drinking or to wash foods, the likelihood that consumers will be exposed to ozone is remote. The concentration of byproducts of ozonation in water is directly dependent upon the level of dissolved organic materials present. The most common organic byproducts of ozonation include acids, aldehydes, ketones, keto-acids, and keto-aldehydes. These low molecular weight organic materials also occur naturally as a result bacterial decomposition, are biodegradable, and possess a low order of toxicity (i.e., they do not appear to pose a health risk to consumers) . However, if bromide ion is present in waters to be treated with ozone, bromate ion and hypobromous acid may be formed and these inorganic oxidation products may be of public health concern. The bromate ion has been reported to cause kidney tumors in certain strains of rats and mice. Hypobromous acid is an effective biocide but can brominate many organic materials producing bromoform

and brominated acids (e.g., brominated acetic acid). The formation of these byproducts can be minimized by controlling pH and concentrations of ozone or by deionizing the water to remove the bromide ion prior to ozonation.

The toxicity of ozone has been studied extensively in many systems from *in vitro* to human. In animals and in humans, the primary route of exposure has been inhalation. Ozone is neither mutagenic nor carcinogenic (although some data suggest that it is a weak tumorigen) but it is a respiratory irritant and may affect respiratory function. The ingestion of ozone is unlikely due to its short half-life in water and the safety of ozonation byproducts is supported by a long history of safe use of ozone in producing potable water in the United States and in Europe, and is approved by Japan, France, and Australia for use in food processing. Available information suggests that the ozonation byproducts formed when foods are treated with ozone are similar to those formed when water is ozonated. Generally, these byproducts do not pose a threat to human health but additional information on the byproducts of ozonation of food is desirable.

Declaration of GRAS

Based on its critical evaluation of available information, the panel concludes that:

> The available information supports the safety of ozone when used as a food sanitizer or disinfectant, and further that the available information supports a **Generally Recognized As Safe (GRAS)** classification of ozone as a sanitizer or disinfectant for foods when used at levels and by methods of application consistent with Good Manufacturing Practices.

Joseph F. Borzelleca Date 25Feb97

Dec M. Graham 1-29-97
Dec M. Grsham Date

John W. Erdman, Jr. 2/8/97 Date

Gordon W. Newell 2/2/97 Date

William H. Glaze 2/19/97 Date

Michael W. Pariza 2/12/97 Date

APPENDIX 1

CURRICULUM VITAE OF PANEL MEMBERS

The *Curriculum Vitae* of the individual members of the Expert Panel are included on the following pages:

Dee M. Graham, Ph. D., Fellow – I. F. T., Chairman

Michael W. Pariza, Ph. D.

William H. Glaze, Ph. D.

Gordon W. Newell, Ph. D., Fellow – A.T. S.

John W. Erdman, Jr., Ph. D., Fellow – l. F. T.

Joseph F. Borzelleca, Ph. D., Fellow – A.T.S., Fellow – l. F.T.

DEE M. GRAHAM

EDUCATION

Ph. D. Iowa State University, 1954. Microbiology and Biochemistry

M. S. Iowa State University, 1951 Dairy Microbiology

B. S. Mississippi State University, 1950 Dairy Manufacturing

A. A. East Central Jr. College, 1946 General Agriculture

ADDRESS

2747 Hutchinson Court
Walnut Creek, CA 94598
tel/fax 510-93 8-0928
email: deeg213050@AOL. COM

SUMMARY

Dr. Graham consults for several clients since retiring as Director of Technical Services for Del Monte Corporation in 1990. Prior experiences include Professor and Department Chair, University of Missouri; Technical Director, Pet Inc.; Associate Professor, Clemson University; and Research Associate, Iowa State University. He served on a variety of National Academy of Sciences committees, including Food Additive Useage, Nutrition and Microbiology, holds patents on infant feeding and aseptic processing, developed several nationally marketed products including SEGO, Del Monte LITE fruit, and No-Salt Added Vegetables. He is a Fellow of the Institute of Food Technologists and has served on the boards of several other associations.

D. M. GRAHAM

Curriculum Vitae

Summary

Dr. Graham works as a private consultant with specialization in Food Safety, Processed Foods Technology, Fruits, Vegetables, and Dairy Products, Aseptic Processing and Packaging, and Electrotechnology.

Prior to his retirement from Del Monte Foods in March 1990, he was Director of Technical Services responsible for line extensions, product improvement, and consumer services; he also directed new product R&D for Del Monte International Products.

In earlier work for Del Monte, Dr. Graham was Director of Technology Development (1984-1986), Director of Central Research (1980-1984), and Associate Director, Dry Grocery Products (1975-1980). His experience includes a wide variety of fruit and vegetable products, process development, analytical chemistry, and microbiology of canned foods.

Formerly, Dr. Graham was Professor and Chairman of the Department of Food Science and Nutrition at the University of Missouri. His professional work has involved a variety of product development activities and research. He has published papers on Caffeine, Food Additive Usage, Nutrition, and Microbiology. He developed several Infant Formulas, Special Dietary Food Products and was instrumental in the development of Lite Fruits, No Salt Vegetables, and Sodium Labeling; he pioneered Aseptic Processing in Flexible Containers for a variety of products.

He has been a member of the Institute of Food Technologists since 1969. Services to IFT include Regional Communicator for the St. Louis/Kansas City area, member of the Expert Panel on Food Safety and Nutrition, Chairman of the Committee on Public Information, Counselor Representative to the Executive Committee, IFT Liaison to CAST and Chairman of the Editorial Committee for *Science of Food and Agriculture.* Currently he is a member of the Awards Committee, past-chairman of the Northern California Section, and a National Counselor of IFT. He was a member of the Food Additives Review Committee of the National Academy of Sciences, National Advisory Committee on Hyperkinesis, and has held several offices, including Director of the American Dairy Science Association.

Currently he serves on the Executive Committee of the California Institute for Food and Agriculture Research, the Food Technology Center for the Electric Power Research Institute, and the Food Engineering Advisory Council at the University of California, Davis.

Professional Experience

1991 to Present	President, R and D Enterprises. Providing research and technical support for the food processing industries.
1991-95	Manager, Food and Agriculture Office, Electric Power Research Institute.
1986-91	Director of Technical Services, Del Monte USA. Responsible for line extensions of cost reductions on existing products, the Consumer Services test kitchens,: and R&D for Del Monte International products.
1984-86	Director of Technology Development, Del Monte Corporation. Responsible for creating and directing a program focused on technology-based opportunity areas, multi disciplinary, long range, beyond the scope of conventional product development.
1980-84	Director of Central Research, Del Monte Corporation. Responsible for Applied Research, Chemistry, Packaging Research, Developmental Engineering and general administration of the Research Center; also, Director of R&D, Dry Grocery Products. Responsible for product development of formulated foods and fruits and vegetable products.
1975-80	Assistant Director of Scientific Research, Del Monte Corporation Research Center, Walnut Creek, California. Directly responsible for all product development activities and, in concert with the Director, coordination and supervision of research in Analytical and Organic Chemistry, Microbiology and Processing, Biochemistry and Nutrition.
1969-75	Professor and Chairman, Department of Food Science and Nutrition, University of Missouri. Organized a newly-formed department, including research, teaching B.S. through Ph.D. programs, and extension activities. Enrollment reached 150 undergraduates and 50 graduate students. Organized industry liaison programs with the processed food industry, other segments such as meat, dairy, poultry and the hotel and restaurant industries. Participated personally in undergraduate teaching, graduate instruction, research on nutrient interaction and energy accounting models.
1968-69	Technical Director, Milk Products Division, Pet Incorporated. Responsible for technical success of new product development, innovation, cost reduction, and quality control on existing products. Supervised Director of Quality Control, Home Economics Research Center, and maintained liaison with marketing, production, and corporate product development services.

COURT APPEARANCES AND RELATED ACTIVITIES

1955 Milk Ordinance, Southern Dairies versus City of Greenville, South Carolina. Appeared as friend of the Court to help clarify issues re microbiological risks.

1973 Special Dietary Foods Hearings. Prepared and presented testimony on behalf of Pet Incorporated in Federal Court, Washington, DC.

1976 Pasteurization of Milk, Alleged Price Fixing -Federal Trade Commission versus the Borden Company and the Great A&P Company. Two appearances in Federal Court, Washington, DC.

1984 Prune Juice. Personal injury (eye); Plaintiff asking $400,000; settled during trial for $60,000. Appeared and testified at Trial, Little Rock, AR.

1986 Defective Can Liner Company. Del Monte Corporation versus Whitaker Corp. Awarded $200,000 in pre-trial hearing. Gave deposition, case settled out of court.

1990 Canned Food – personal injury (eye); Wagner versus Nalley's Fine Foods. Reviewed depositions, directed laboratory analysis, summarized evidence; settled out of court by negotiation for $500,000.

1990 USA versus Archer-Daniels-Midland Company and Nabisco Brands, Inc. concerning development of High Fructose Corn Syrup. Gave deposition and appeared in trial.

1991 Nestle Holdings versus Commissioner, IRS. Reviewed court documents regarding several research components and unpatented technology. Provided reports, advice and counsel to District Counsel.

1993 Nestle Holdings versus Commissioner, IRS. Developed expert reports on 2 phases of trial.

1994 Nestle holdings versus Commissioner, IRS. Prepared expert reports on two phases of trial, and appeared as Expert Witness in Tax Court on June 1, 1994.

1996 Hastings versus Campbell Soup Co. Analyzed background data, provided counsel to plaintiff's ' attorney, settled out of court.

Special Accomplishments

Health related Food Claims – Developed a petition for a new regulation on health claims for food products, in response to a request from the Commissioner of Food and Drugs; Chaired an ad hoc committee of NFPA, which developed the necessary data base, supporting documents, and draft petition.

Iodine Workshop – Chaired a workshop on adventitious Iodine Contamination of Foods, under auspices of the American Medical Association. The closed conference led to voluntary action programs in two key industry segments which significantly reduced the danger of excess iodine ingestion on a national level and precluded the need for regulatory action.

Nutrition Labeling – Served on a joint committee of the Milk Industry Foundation and the American Dairy Science Association. Developed a comprehensive Labeling Manual which was distributed throughout the United States for use by the Dairy Industry, State and Federal Regulatory Agencies as a guideline for the proper nutrition labeling of milk and milk products.

Food Additive Usage – Member of an ad hoc committee of the National Academy of Sciences under contract to the Food and Drug Administration. Developed methods in a pilot survey and then conducted a series of nation-wide surveys of the usage of food additives. This provided basic data necessary for the re-evaluation of safety of GRAS list and regulated food additives.

Food Regulation Hearings – Testified in the Food and Drug Hearings related to Foods for Special Dietary Purposes. Testimony coincided with several points which were adopted in the final regulation when promulgated, particularly regarding levels of fortification with trace nutrients.

Testified in Federal Trade Commission case concerning the history, development, and role of pasteurization in protecting consumer from food borne diseases, particularly through milk and milk products.

Food and Agriculture Office, EPRI— Developed a program of fundamental research, technology transfer, and technical service for the Electric Power Research Institute.

Process Water Recovery—Developed a joint industry demonstration project, including a 48 foot by 8 foot mobile laboratory to study the feasibility of recovering food process water. Results from 18 plant sites.showed profit improvement by recovery of previously lost food solids, reduction of waste burden, major reduction in water usage, and decreased waste disposal burden. Funding was provided by the Electric Power Research Institute, various utility companies, California League of Food Processors, and Pacific Northwest Laboratories, Department of Energy.

SEGO diet — developed a line of canned liquid, dehydrated instant, and fresh refrigerated products in the "900 calorie daily diet" concept. Highly successful in national distribution through grocery stores. Beginning in 1961 and continuing to date.

PET Instant Nurser — U.S. Patent No. 3,248,231 — developed formulation, process, and assisted in package design for a disposable infant feeding system including formulas for newborn and mature infants.

PET Non-Dairy Creamer — developed a "pioneer" synthetic dairy product from non-dairy ingredients, including products for grocery store distribution, institutional trade, and vending machine applications.

Aseptic Bag-In-Box — developed unique process for sterilizing liquid products and aseptically packaging them in flexible plastic bags. Applied successfully on commercial scale with ice milk and ice cream mix. Negotiated license for production of the equipment. Adopted Scholle and FranRica systems for bulk aseptic packaging of Del Monte Crushed Pineapple and Pineapple Concentrate in flexible bags.

Del Monte Lite Fruits — developed line of Peaches, Pears, and Fruit Cocktail formulated to meet reduced calorie claim and excellent consumer acceptance.

Del Monte No-Salt Vegetables — developed line of eleven major vegetable products formulated without salt and supporting reduced sodium labels and good consumer acceptance.

Protection of Milk from Iodine^{131} Contamination — developed for special handling of fluid milk to assure safety from radioactive iodine debris resulting from nuclear explosion, under contract for the United States Department of Agriculture. Study also yielded valuable information on keeping quality of milk in normal handling.

Reformulated Del Monte Pudding Cup to eliminate bitter/rancid flavor problem.

Reformulated Cream Style Corn to improve color and consistency with cost reduction of one million dollars per year.

Packaging-- directed the formation, staffing, and equipping of a highly creative packaging group proficient in metal, glass, laminated plastic, and fiberboard packaging technology. Generated over $2 million in cost reductions on existing products in 1982.

Environmental Protection – developed and directed plans for coping with an accidental spill of chromium solution from a major can manufacturing facility. Effected clean-up of affected area and installed system to prevent recurrent. Developed and directed plan for coping with a large accidental spill of ethylene dibromide in a major agricultural

area, including safeguards to protect the deep aquafer and water supply of nearby residents.

Professional and Scientific Associations

American Dairy Science Association – Chairman of Dairy Food Division, 1970; Director, 1966-69; General Program Chairman, 1964; Manufacturing Section Chairman, 1963; various committees; member since 1950.

Institute of Food Technologists – Regional Communicator, Midwest Region 1973-74; Member Expert Panel on Food Safety and Nutrition, 1974; Chairman, Committee on Public Information, 1978-82; Member, Committee on Research Needs, 1983-86; Committee on Nominations and Elections, 1984-89; Fellows Awards Jury, 1992-94, Chair 1996; President Nominee 1991.

National Academy of Sciences – Member of Committee on Food Protection 1971-75; Chairman of Subcommittee on Food Technology, 1974; Member of Food Additive Review Committee 1970-83; 1987-90.

Previous affiliations – American Academy of Pediatrics, Evaporated Milk Association, National Conference of Interstate Milk Shippers.

Honoraries

Alpha Zeta
Sigma XI
American Men of Science
Who's Who in America
Who's Who Worldwide 1993-94
Fellow, Institute of Food Technologists

Council for Agricultural Science and Technology

1. Significant Issues in Nutrition. C.A.S.T. Report No. 57, July 19, 1976.

American Medical Association

1. Current Exposure to Iodine. Workshop and Summary Report Scottsdale, -AZ., November 13-14, 1979.

Advisory Boards

1. Dairy Research Incorporated.
2. Technical Research Advisory Committee, California Dairy Council.
3. National Academy of Sciences – Military Personnel Supplies.
4. College of Agriculture, University of California, Davis. Dean's Advisory Committee.
5. Chairman of Editorial Board, Science of Food and Agriculture.
6. Department of Nutrition Sciences, San Jose State University, San Jose. Dean's Advisory Committee.
7. Food Engineering Advisory Council, University of California, Davis.
8. Food Science and Technology Advisory Council, University of California, Davis.
9. Food Technology Center Board of Directors, Electric Power Research Institute, Palo Alto, CA.

Special Training

Utilities and Food Processors – Partners in Development Workshop. EPRI. October 1990.

Director's Briefing, EPRI, November 1992.

Food Irradiation Update. University of California, Davis. March 1985.

IMS Management Seminar, March 1983.

Boomerang II – Management Training Program in Equal Opportunity, 1981.

Managing for Productivity – Del Monte Corporation. Ten Session Management Course, 1980.

MediaCom Program Individualized Instruction for Public Speaking and Television. Carl Byoir and Associates, 1979.

Institute of Food Technologists Seminar on Communications for Committee on Public Information and Regional Communicators, 1973.

Executive Program in Business Administration, Columbia University, 1963.

American Management Association: President's Association Seminar, 1966; New Product Planning Seminar, 1967; Seminar on Liaison between Marketing and R&D, participant 1962 and lecturer 1966.

IBM Executive Seminar on Computer Technology, 1966.

Publications

1. The Carrier State of Lactic Streptococcus Bacteriophage, Graham, Nelson, and Parmelee. J. Dairy Science, 35:813-822, 1952.

2. The Presence and Persistence of Bacteriophage in Commercial Lactic Cultures. Graham, Nelson, and Parmelee. Milk Plant Monthly, December 1952, pp. 22-24.

3. Growth Characteristics of the Lactic Streptococcus Bacteriophage. Graham and Potter. Applied Microbiology, 1:138-142, 1953.

4. Mutation to Bacteriophage Resistance in Pure Cultures of Lactic Streptococci. Graham and Nelson. J. Dairy Science, 36:563, 1953.

5. Effect of Crystal Violet and other Inhibitors on Lactic Streptococcus Bacteriophage. Graham and Nelson. J. General Physiology, 37:121-138, 1954.

6. Mechanical Draining, Inoculating and Hooping of Blue Mold Cheese Curd. Graham and Rowland. J. Dairy Science, 42:1096-1097, 1957.

7. Selection of Penicillium Strains for Blue Cheese. Graham. J. Dairy Science, 41:719, 1958.

8. Production, Distribution, and Use of Frozen Active Lactic Cultures. Simmons and Graham. Southern Dairy Products Journal, October 1958.

9. Maintenance of Active Lactic Cultures by Freezing as an Alternate to Daily Transfer. Simmons and Graham. J. Dairy Science, 42:363-364, 1959.

10. The Effect of Reduced Oxygen Concentration Versus Irradiation Dosage on Evaporated Milk. Graham and Porter. Quartermaster Food and Container Institute for the Armed Forces, Contract Research Reports, File S-747, April-1962.

11. Continuous Irradiation Sterilization with Vacuum Concentration and Aseptic Canning of Milk. Porter, Graham, and Jaynes. Abstract of Paper Presented at 85th Annual Meeting, American Dairy Science Association, June 1963.

12. Practical Experiences in the Use of Carrageenan Stabilizers in Evaporated Milk and Related Products. Paper presented before 5th Biennial Milk Concentrates Conference, Davis, California, September 1965. Bound proceedings published.

13. Disposable Infant Nurser Package and Method of Making Same. U.S. Patent No. 3,248,231. Dated April 26, 1966.

14. What Industry Wants in the Dairy Manufacturing Graduate. Paper presented before the Education Symposium of the American Dairy Science Association Annual Meeting, June 1966, Corval lis, Oregon. Published in the Journal of Dairy Science, 50:927, 1967.

15. Industrial View of Imitation Milk Products. Graham. J. Dairy Science, 53:103-105, 1970.

16. Industry Internships - A Good Deal, Graham. Food Product Development, p.6, 1970.

17. Alteration of Nutritive Value Resulting from Processing and Fortification of Milk and Milk Products. Graham. J, Dairy Science, 57:738-745, 1974.

18. Looking at a New Market, Shelley and Graham. National Ice Cream Retailers Association. Bulletin, July 1974. .

19. Alteration of Nutritive Values by Processing and Fortification of Milk and Milk Products. Graham. Cultured Products Journal, 9:18-22, 1974.

20. Animal Protein - Substitute and Extenders. Edmondson and Graham. Journal of Animal Science, 41, 41:698-702, 1975.

21. Review of the 1970 NAS GRAS Pilot Survey (Phase I) and the 1971 NAS Comprehensive Survey (Phase II). Graham. Food Drug Cosmetic Law Journal, 31(1):26-31, 1976.

22. Food Additives and Hyperactivity. Graham. Cereal Foods World, 21(6):248-253, 1976.

23. Egg Usage in Restaurants and Mass Feeding Institutions, Arendt and Graham. Poultry Science, 55:942-949, 1976.

24. Why Enrich or Fortify Foods. Graham and Hertzler. J. of Nutr. Educ., Vol. 9, No. 4, 1977.

25. Caffeine - Its Identity, Dietary Sources, Intake and Biological Effects. Graham. Nutr. Reviews, Vol. 26, No. 4, 1978.

26. Separation and Characterization of Polyphenol Oxidase from Cascabelle Hot Chilies. Liu, Graham and Niven. Paper 321.

27. Benefits and Costs of Food Additive Regulations. Graham. Presented at the joint IFT-IUFOST Basic Symposium. New Orleans. June 1980. Published in "Impact of Toxicology on Food Processing". AVI Publishing Company, Inc., Westport, CN., pp. 28-34, 1981.

28. National Advisory Committee on Hyperkinesis and Food Additives; Final Report to the Nutrition Foundation, October 1980.

29. 1987 Poundage and Technical Effects Update of Substances Added to Food. Committee on Food Additives Survey Data, Food and Nutrition Board, Institute of Medicine, National Academy of Sciences, December 1989.

30. Assessing Dietary Exposure to Food Additives: A New Approach. Graham, Filer and Bigelow. Food Technology, 44:94-96. July 1990.

31. Consumption Patterns: Estimating Human Exposure to Specific Substances in the American Food Supply. Graham. Food Technology, 46:118-120. March 1992.

32. A New Approach for Assessing the Dietary Exposure to Food Additives. Graham, Filer and Bigelow. Critical Reviews in Food Science and Nutrition, 32(2):157-160. 1992.

Committee on Nutrition Publications,
American Academy of Pediatrics

The publications are developed as a committee function and generally published in Pediatrics. In 1964, Dr. Graham served as special consultant to the committee and was appointed as a member of the Technical Advisory Group in 1956 for a three year term with reappointment in 1968. During this period, he had input on the following publications:

1. Prepared Infant Formulas and Commercial Formula Services. Pediatrics, Vol. 36, No. 2, August 1965.

2. Protection of the Infant Diet: Government and Industry. Pediatrics, Vol. 36, No. 4, October 1965.

3. Vitamin B_6 Requirements in Man. Pediatrics, Vol. 38, No. 6, Part I, December 1966.

4. Statement on Compulsory Testing of Newborn Infants for Hereditary Metabolic Disorders. Pediatrics, Vol. 39, No. 4, April 1967.

5. National Nutritional Survey of Pre-School Children. Pediatrics, Vol. 39, No. 4, April 1967.

6. Absence of Vitamin D in Nonfat Dry Milk. Pediatrics , Vol. 40, No. 1, July 1967.

7. Nutritional Management in Hereditary Metabolic Disease. Pediatrics, Vol. 40, No. 2, August 1967.

8. Baby Foods as Special Dietary Foods. Pediatrics, Vol. 40, No. 5, November 1967.

9. Proposed Changes in Food and Drug Administration Regulations Concerning Formula Products and Vitamin - Mineral Dietary Supplements for Infants , Pediatrics, Vol. 40, No. 5, November 1967.

10. The Relation Between Infantile Hypercalcemia and 'Vitamin D – Public Health Implications in North America. Pediatrics, Vol. 40, No. 6, December 1967.

11. Filled Milks, Imitation Milk, and Coffee Whiteners, Pediatrics, Vol. 49: 770-775, 1972.

Committee on Food Protection
National Academy of Sciences.

The publications are developed as a committee function and generally published by the Academy in the, form of bound reports or books. In 1970 Dr. Graham was appointed to an Ad Hoc Subcommittee to study the usage of GRAS list food additives and appointed to the committee on Food Protection in 1972. In this capacity he had input to the following publications :

1. Development and Testing of a Survey Procedure for the Reevaluation of Safety of Substances Generally Recognized as Safe (GRAS Pilot Survey) Subcommittee on Review of the GRAS List. National Academy of Sciences/National Research Council. December 1970. 35PP + exhibits.

2. A Comprehensive Survey of Industry on the Use of Food Chemicals Generally Recognized as Safe (Comprehensive GRAS-Survey) Subcommittee on Review of the GRAS List- Phase II. National Academy of Sciences/National Research Council, September 1972. 41pp + exhibits.

3. Radionuclides in Foods. Committee on Food Protection, National Academy of Sciences. 1973. 97pp.

4. The Use of Chemicals in Food Production, Processing Storage, and Distribution. Committee on Food Protection, National Academy of Sciences. 1973. 34pp.

5. Toxicants Occurring Naturally in Foods. Committee on Food Protection, National Academy of Sciences. 1973. 624pp.

6. World Food and Nutrition Study: Enhancement of Food Production for the United States. Report of the Board on Agriculture and Renewable Resources, National Academy of Sciences/National Research Council. (Participant in workshop and author of Section V, Food Science and Technology). 1975. 174pp.

7. Technology and Fortification of Foods. Subcommittee on Food Technology, Committee on Food Protection. National Academy of Sciences/National Research Council. (Chairman of Subcommittee for Workshop). 1975. 114pp.

8. Estimating' Distribution of Daily Intakes of Certain GRAS Substances. Committee on GRAS List Survey–Phase III. Food and Nutrition Board, Assembly of Life Sciences. National Academy of Sciences/National Research Council, Washington, DC December 1976. 22pp and appendices.

9. 1982 Poundage Update of Food Chemicals. Committee on Food Additives Survey Data, Food and Nutrition Board, Commission on Life Sciences, National Research Council, Washington, DC. 1984, 558pp.

Video New Release

Too Much Salt? 1985-V. Gprdpm Mews, San Francisco, Over 33 million impressions on four major net works.

Chapters in Books

1. Evaporated Milk History in Encyclopedia of Food Technology edited by A.H. Johnson and M. S. Peterson. AVI Publishing co., Westport, Connecticut, 1974.

2. Prospects for Milk Supplies in the United States in New Protein Foods, Vol. 3, Animal protein Supplies, edited by A. A. Altschuyl and H. L. Wilcke. Academic Press, Inc., New Yeork, NY, 1978.

3. Impact of Toxicolory on Food Processing, edited by John C. Ayres and John C. Kirschman. Chapter 4. Benefits and Costs of Food Additive Regulations. AVI Publiching Co., 1981.

4. Concentrated and Dry Milks and Wheys in the Third Quarter of the 20th Century. J. Dairy Sci., 64 : 1055-1062.

Publications of the Food and Agriculture Office for the Electric Power Research Institute

Industry Briefs

- Wet Corn Milling (Vol. 1 #1R)
- Dairy Industry (Vol. 1 #2)
- Alcoholic Beverages (Vol. 1 #6R)
- Bakery Products (Vol. 1 #10)
- Processed Fruits and Vegetables (Vol. 1 #11)
- Fats and Oils (Vol. 1 #12)
- Sugar and Confectionery (Vol. 1 #13)
- Breakfast Cereals (Vol. 1 #14R)

TechCommentaries

- Freeze Concentration (Vol. 1 #I)

- Membrane Processes (Vol. 1 #2)
- Pinch Technology (Vol. 1 #3)
- Industrial Heat Pumps (Vol. 1 #4)
- Pressure Swing Adsorption (Vol. 2 #2)
- Electroseparation Processes (Vol. 4 #l)

TechApplications

- Food Processing Using Microwaves (Vol. 2 #1)
- ASDs In Food Processing (Vol. 2 #3)
- Membrane Separation in Food Processing (Vol. 3 #l)
- Heat Pumps in Food Processing (Vol. 3 #4)
- Ozonation of Cooling Tower Water in Food Processing (Vol. 4 Y4)
- Effluent Reduction in Dye Processing (Vol. 4 #5)
- Ultrafiltration in Food Processing (Vol 4 #6)

Innovators

- Pinch Technology Helps NYPA Identify Energy Saving Options

Brochures

- Industrial Process Heat Recovery (CUD.3027.5.69)
- Electric Drives Versus Nonelectric Drives: Economic Evaluation Procedures (BR-100425)

Videos

- Freeze Concentration - The Natural Way to Freshness

Reports

- Heat Pumps in Evaporation Processes (EM-4693)
- Heat Pumps in Complex Heat and Power System (EM-4694)
- Radio-Frequency Dielectric Heating (EM-4949)

- The Use of Membranes in Hybrid Separation Systems (EM-5231)
- Industrial Applications of Freeze Concentration Technology (EM-5232)
- Industrial Heat Pump Manual (EM-6057)
- Microwave Vacuum Drying of Food Products (CU-6247)
- Freeze Concentration of Dairy Products (CU-629)
- Design of Industrial Process Refrigeration System (CU-6334)
- Optimizing Energy Use in the Process Industries 4 Vols. (CU-6645)
- Food Industry Scoping Study (CU-6755)
- Pinch Technology: A Primer (CU-6775)
- Regulating Vacuum Speed with Feedback Control (TR-100173)
- Solid-State Speed Controllers for Single-Phase Capacitor Motors (TR-100174)
- Performance of Microprocessor Controllers (TR-100175)
- Automatic Restart of Complex Irrigation Systems (TR-100176)
- Improving Management of Low-Temperature Dry of Corn (TR-100445)
- Electrotechnology Applications in Cereal Grain Processing: An Evaluation of Microwave Processing in Rice Parboiling (TR-100448)
- Using Electric Fields to Control Insect Population in Stored Grains and Forages (TR-100971)
- Improving Dairy Farm Profitability in Vermont Throw Energy Efficiency and DSM Opportunities (TR-100972)
- Pinch Technology/Process Optimization Case Studies– 5 Vols. (TR-101147)
- Separation and Concentration Technologies for Industrial Wastewater Treatment (final report)
- Commercialization Plan for Treatment of lndustrial Wastewater Using Electroseparation Techniques (final report)

MICHAEL W. PARIZA - CURRICULUM VITAE

Born in Waukesha, Wisconsin - March 1943. Married, 3 children.

Academic Rank:

Director, Food Research Institute; Wisconsin Distinguished Professor and Chair, Department of Food Microbiology and Toxicology.

Education:

Ph.D. Kansas State University 1973, Microbiology

M.Sc. Kansas, State University 1969, Microbiology

B.Sc. University of Wisconsin-Madison 1967, Bacteriology

Professional Experience:

- Kansas State University: Graduate Teaching Assistant, Graduate Research Assistant, 1967-1969.
- U.S. Army (Armed Forces Institute of Pathology, Washington, D.C.): Biological Sciences Assistant, 1969-1971.
- Kansas State University: Graduate Teaching Assistant, Graduate Research Assistant, 1971-1973.
- The University of Wisconsin-Madison (McArdle Laboratory for Cancer Research): NIH Postdoctoral Traineeship with Professor Van R. Potter, 1973-1976.
- The University of Wisconsin-Madison (The Food Research Institute, Department of Food Microbiology and Toxicology): Assistant Professor, 1976-1981; Associate Professor, 1981-1984; Professor, 1984 Present; Associate Department Chair, 1981-1982; Department Chair, 1982-Present; Director, Food Research Institute, 1986-present.
- Wisconsin Distinguished Professor, 1993-present.
- Affiliate appointments at the University of Wisconsin: Wisconsin Clinical Cancer Center; Environmental Toxicology Center; Department of Nutritional Sciences; Department of Food Science.

Membership in Scientific Organizations:

The American Association for Cancer Research

The American Society for Microbiology

The American Association for the Advancement of Science

The Society of Sigma Xi

The Institute of Food Technologists

The Toxicology Forum

FASEB (The American Institute of Nutrition; The American Society for Clinical Nutrition)

The American Chemical Society

Special Professional Recognition:

— Co-Chair of Organizing Committee, Co-Editor of Proceedings, and Keynote Speaker for an international symposium entitled "Calories and Energy Expenditure in Carcinogenesis," held in Washington, DC, in 1986.

— Chair, Food Microbiology Division of the American Society for Microbiology, 1986/87.

— Member, Board of Trustees, International Life Sciences Institute - North America, 1986-present.

— Invited twice (1986 and 1989) to lecture at the annual/American Cancer Society's Science Writers Symposium.

— Invited to lecture at a symposium on Diet and Health, held in Vevy, Switzerland, in 1987; sponsored by the Nestle Company.

— Sabbatical at Colworth House in Great Britain, guest of the Unilever Company, summer, 1987.

— Chair, Committee on Diet and Health for CAST (the Council on Agricultural Science and Technology). Report issued in 1987.

— Invited lecture at an international conference on Anticarcinogens and Antimutagens in the Diet, held in Ohito, Japan, in 1988; also lectured at the Toyama Public Health Laboratory, and the Kikkoman Company.

— Author of Food, Diet, and Health Relationships for the Issues and Challenges Section, United States Department of Agriculture Five-Year Plan, 1988.

— Invited lecture at an international symposium on Diet and Cancer held at the Karolinska Institute, Stockholm, Sweden, in 1989.

— Invited lecture at a meeting on Biotechnology and Food Safety held at Cornell University, Ithaca, NY, in 1989.

— Invited to lecture at an international symposium on Anticarcinogens in the Diet, held in Charleston, SC, in 1989.

— Member, Document Drafting Committee, International Food Biotechnology Council, 1989/90.

— Invited to lecture at an international symposium on Food Biotechnology sponsored by the International Food Biotechnology Council, held in Washington, DC, in 1989.

— Chair of Organizing Committee and speaker at an international symposium, Mutagens and Carcinogens in the Diet, held in Madison, WI, in 1989.

— Member, Scientific Advisory Committee for Universal Foods Corporation, 1989 to present.

— Invited to lecture on anticarcinogen research in two separate symposia at the 1990 annual FASEB meeting.

— Invited to lecture at an international conference on food safety at Michigan State University, in 1990.

— Invited to lecture on risk assessment at an EPA-sponsored symposia on Pesticidal Transigenic Plants, held in Annapolis, MD, in 1990.

— Advisor on toxicology matters to the Madison Metropolitan Sewerage District Commission, 1990 to present.

— Invited to lecture at a symposium on Anticarcinogens, sponsored by the National Cancer Institute and held in San Diego, CA, in 1991.

— Invited to lecture at an international symposium on cancer prevention organized by former Surgeon General C. Everett Koop, held in Washington, DC, in 1991.

— Keynote speaker at the annual convention of the National Association of State Departments of Agriculture, held in Las Vegas, NV, in 1991.

— Invited to lecture on risk assessment at symposium on "Industrial Ecology," sponsored by the National Academy of Sciences and held in Washington, DC, in 1991.

— Invited to lecture at the 5th International Congress on Oxygen Radicals, held at Kyoto, Japan, in 1991.

— Breakfast speaker at mid-year meeting of the National Association of State Departments of Agriculture, held in Washington, DC, in 1992.

— Invited to lecture on natural toxicants at symposium on plant Biotechnology sponsored by The Institute of Medicine and held in Irvine, CA, in 1992.

— Invited to lecture at symposium on anticarcinogens from dairy products, IFT Annual Meeting, 1992.

— Invited to lecture at symposium on anticarcinogens, ACS Annual Meeting, 1992.

— Member, 1993 Program Planning Committee, American Association for Cancer Research.

— Keynote speaker at the 1993 annual meeting of the Weed Science Society of America.

— Member, Institute of Medicine's Food Forum, 1993-present.

— Member, National Academy of Sciences Committee on Comparative Toxicity of Naturally Occurring Carcinogens, 1993-present.

— Invited participant at the U.S. Congressional staff briefing conducted by the Environmental and Energy Study Conference on the safety and regulation of genetically engineered foods, 1993.

— Presented two invited lectures at the Health Protection Branch, Ottawa, Canada, November 1993.

— Lecturer and session chair for two food safety symposia sponsored by the Ceres Forum of Georgetown University, Fall 1993.

— Keynote lecturer and session chair for symposium on food safety, 1994 annual convention of the American Association for the Advancement of Science.

— Invited participant for two meetings of the U.S.-Japan Cooperative Cancer Research Program, held in Honolulu in March 1994.

— Invited participant (lecture and session chair) at the 1994 summer Toxicology Forum meeting.

— Invited to lecture entitled "The Effect of Diet on National Health Care Costs" at the National Planning Association's Food and Agriculture Committee meeting of September 9, 1994 held in Washington, D.C.

— Invited to lecture entitled "A Review of Foodborne Pathogens and Risk" at the annual meeting of the American Dietetic Association in a symposium entitled *Meat and Poultry Safety: From Farm to Table*, held on October 18, 1994 in Orlando, FL.

— Invited panelist at a session entitled "Interrelationships of Food, Diet, and National Health" at the annual meeting of the National Association of State Universities and Land-Grant Colleges held on November 6, 1994 in Chicago, IL.

— Invited participant in a conference entitled "National Forum on Meeting the Challenge: Health, Safety, and Food for America" sponsored by the White House Office of Science and Technology Policy held on November 21-22, 1994 in Washington, DC.

— Invited to lecture entitled "Foodborne Microbial Pathogens" at the International Food and Lifestyles Media Conference, January 30, 1995, Las Vegas, NV.

— Co-organizer of and participant in a U.S.-Japan Cooperative Cancer Research Program, March, 1995, Maui, HI.

— Testified at a hearing on the FDA and the future of the American biomedical and food industries, held by the U.S. Senate Committee on Labor and Human Resources, chaired by Senator Nancy Kassebaum, April 5, 1995, Washington, DC.

— Invited participant in an IFT Basic Symposium on lipids and health, June 2-3, 1995, Anaheim, CA.

— Discussed reform of the Delaney Clause at a press conference on reforming the federal regulatory process held at the Senate Office Building, July 12, 1995, Washington, DC.

Research Focus:

Conjugated linoleic acid

Patents:

1. Pariza, M.W., and Ha, Y.L. Methods of preventing oxidation, quenching singlet oxygen, and inhibiting mold growth and novel compositions thereof. U.S. 5,017,614

2. Pariza, M.W., and Ha, Y.L. Methods of cheating metal and novel compositions therefor. U.S. 5,070,104

3. Pariza, M.W., and Ha, Y.L. Octadecadienoic phospholipid esters, antioxidant and mold inhibiting compositions. U.S. 5,208,356

4. Pariza, M.W., and Nagahara, A. Antitumor agent. Japanese patent application (Pending).

5. Cook, M.E., and Pariza, M.W. Methods for preventing weight loss, reduction in weight gain, and anorexia due to immune stimulation. U.S. 5,430,066

6. Cook, M.E. and Pariza, M.W. Method for increasing the efficiency of feed conversion in animals. U.S. 5,428,072

7. Cook, M.E., Pariza, M.W., and Park Y. Method for reducing body fat in animals. U.S. patent application (allowed).

8. Cook, M.E., Pariza, M.W., Lee, K.N., and Wentworth, B.C. Method for controlling bird populations. U.S. patent application (pending).

9. Cook, M.E., Pariza, M.W., Yang, X., and Devoney, D. Methods of treating animals to maintain or increase CD-4 and CD-8 cell populations. U.S. patent application (pending).

Publications:

1. Pariza, M. W. and Iandolo, J. J. 1969. Coagulase production by injured *Staphylococcus aureus* MF-31 during recovery. Appl. Microbiol. 17:836-838.

2. Rosenthal, L. J., Martin, S. E., Pariza, M. W. and Iandolo, J. J. 1972. Ribosome synthesis in thermally shocked cells of *Staphylococcus aureus.* J. Bacteriol. 109:243-249.

3. Pariza, M. W. and Iandolo, J. J. 1974. Base ratio and DNA homology studies on six *Staphylococcus aureus.* Appl. Microbiol. 27:317-323.

4. Pariza, M. W. and Iandolo, J. J. 1974. Determination of genome size of selected bacteriophages of *Staphylococcus aureus*. Appl. Microbiol. 28:510-512.

5. Pariza, M. W., Becker, J. E., Yager, J. D., Jr., Bonney, R. J. and Potter, V. R. 1974. Enzyme induction in primary cultures of rat liver parenchymal cells, pp. 267-284. In W. Nakahara, T. Ono, T. Sugimura and H. Sugano (eds.) Differentiation and control of malignancy of tumor cells. University of Tokyo Press, Tokyo, Japan.

6. Kletzien, R. F., Pariza, M. W., Becker, J. E. and Potter, V. R. 1975. A method using 3-O-methyl-D-glucose and phloretin for the determination of intracellular water space of cells in monolayer cultures. Anal. Biochem. 68:537-544.

7. Kletzien, R. F., Pariza, M. W., Becker, J. E. and Potter, V. R. 1975. A "permissive" effect of dexamethasone on the glucagon induction of amino acid transport in cultured hepatocytes. Nature 256:46-47.

8. Pariza, M. W., Yager, J. D., Jr., Goldfarb, S., Gurr, J. A., Yanagi, S., Grossman, S. H., Becker, J. E., Barber, R. A. and Potter, V. R. 1975. Biochemical, autoradiographic and electron microscopic studies on adult rat liver parenchymal cells in primary culture, pp. 137-167. In L. E. Gerschenson and E. B. Thompson (eds.) Gene expression and carcinogenesis in cultured liver. Academic Press, New York.

9. Yager, J. D., Jr., Pariza, M. W., Becker, J. E. and Potter, V. R. 1975. DNA synthesis in primary cultures of parenchymal cells isolated from regenerating rat liver, pp. 148-151. In R. Lesch and W. Reutter (eds.) Liver regeneration after experimental injury. Stratton Intercontinental Medical Book Corporation, New York.

10. Pariza, M. W., Yanagi, S., Gurr, J. A., Morris, H. P. and Potter, V. R. 1976. Ornithine decarboxylase activity and DNA synthesis in Morris hepatomas 5123-C and 7800. Life Sci. 18:39-48.

11. Kletzien, R. F., Pariza, M. W., Becker, J. E., Butcher, F. R. and Potter, V. R. 1976. Induction of amino acid transport in primary cultures of adult rat liver parenchymal cells by insulin. J. Biol. Chem. 251:3014-3020.

12. Pariza, M. W., Yanagi, S., Gurr, J. A., Morris, H. P. and Potter, V. R. 1976. Fasting does not abolish the diurnal oscillation of ornithine decarboxylase in Morris hepatoma 5123-C. Life Sci.19:1553-1558.

13. Pariza, M. W., Butcher, F. R., Kletzien, R. F., Becker, J. E. and Potter, V. R. 1976. Induction and decay of glucagon-induced ammo acid transport in primary cultures of adult rat liver cells: Paradoxical effects of cycloheximide and puromycin. Proc. Natl. Acad. Sci. U.S.A. 73:4511-4515.

14. Pariza, M. W., Kletzien, R. F., Butcher, F. R. and Potter, V. R. 1976. Inductions by hormones added singly, simultaneously or sequentially: What cultured hepatocytes can tell us about metabolic regulation in the whole animal. Adv. Enzyme Regulation 14:103-115.

15. Kletzien, R. F., Pariza, M. W., Becker, J. E. and Potter, V. R. 1976. Hormonal regulation of amino acid transport and gluconeogenesis in primary cultures of adult rat liver parenchymal cells. J. Cell . Physiol. 89:641-646.

16. Pariza, M. W., Butcher, F. R., Becker, J. E. and Potter, V. R. 1977. Cyclic AMP-independent induction of amo acid transport by epinephrine in primary cultures of adult rat liver cells. Proc. Natl. Acad. Sci. U.S.A. 74:234-237.

17. Pariza, M. W., Kletzien , R. F. and Potter, V. R. 1977. A model for the "permissive" effect of glucocorticoids on the glucagon induction of amino acid

transport in cultured hepatocytes, pp. 379-388. In R. T. Acton and J. D. Lynn (eds.) Proc. International Cell Culture Congress. Academic Press, New York.

18. Goldfarb, S., Barber, T. A., Pariza, M. W. and Pugh, T. W. 1978. Lipid synthesis and ultrastructure of adult rat hepatocytes during their first twenty-four hours in culture. Exptl. Cell Res. 117:39-46.

19. Giger, 0. and Pariza, M. W. 1978. Depression of amino acid transport in cultured rat hepatocytes by purified enterotoxin from *Clostridium Perfringens.* Biochem. Biophys. Res. Commun. 82:378-383.

20. Saccone , G. T. P. and Pariza, M. W. 1978. Effects of dietary butylated hydroxytoluene and phenobarbital on the activities of ornithine decarboxylase and thymidine kinase in rat liver and lung. Cancer Lett. 5:145-152.

21. Pariza, M. W., Ashoor, S. H., Chu, F. S. and Lund, D. B. 1979. Effects of temperature and time on mutagen formation in pan-fried hamburger. Cancer Lett. 7:63-69.

22. Pariza, M. W., Ashoor, S. H. and Chu, F. S. 1979. Mutagens in heat-processed meat, bakery and cereal products. Food Cosmet. Toxicol. 17:429-430.

23. Pariza, M. W., 1979. Food safety: from the eye of a hurricane. Professional Nutritionist 11: 1 l-14 (commissioned article).

24. Giger, O. and Pariza, M. W., 1980. Mechanism of action of Clostridium Perfringens enterotoxin: effects on membrane permeability and amino acid transport in primary culture of adult rat hepatocytes. Biochem. Biophys. Acta 595:264-276.

25. Ashoor, S. H., Dietrich, R. A., Chu, F. S. and Pariza, M. W. 1980. Proline enhances mutagen formation in ground beef during frying. Life Sci. 26:1801-1805.

26. Gayda, D. P. and Pariza, M. W. 1980. Rat hepatocytes in primary monolayer culture: a tool for investigating the regulation of carcinogen metabolism, pp. 1165-1168. In M. J. Coon, A. H. Conney, R. W. Estabrook, H. V. Gelboin, J. R. Gillette and P. J. O'Brien (eds.) Microsomes, drug oxidations and chemical carcinogenesis, Vol. II. Academic Press, New York.

27. Saccone , G. T. P. and Pariza, M. W. 1981. Enhancement of hepatic microsome-mediated bacterial mutagenesis by the rat liver soluble protein fraction. Mutat. Res. 88:135-145.

28. Gayda, D. P. and Pariza, M. W. 1981. Activation of aflatoxin B_1 by primary cultures of adult rat hepatocytes: effects of hepatocyte density. Chem. Biol. Interactions 35:255-265.

29. Saccone , G. T. P., DasGupta, B. R. and Pariza, M. W. 1981. Enhancement of N-hydroxy-2-aminofluorene bacterial mutagenicity by the soluble protein fraction from rat liver and partial purification of the enhancement activity. Cancer Res. 41:4600-4605.

30. Pariza, M. W. 1982. Mutagens in heated foods. Food Technol. 36:53-56.

31. DasGupta, B. R. and Pariza, M. W. 1982. Purification of two *Clostridium perfringens* enterotoxin-like proteins and their effects on membrane permeability in primary cultures of adult rat hepatocytes. Infect. Immun. 38:592-597.

32. Pariza, M. W. (Consulting Reviewer). 1982. *Oncolgy Overview* on mutagens and carcinogens in cooked, smoked and charred foods. National Technical Information Service, Springfield, VA. Document #PBB82-922914.

33. Hargraves, W. A., Dietrich, R. A. and Pariza, M. W.1982. A new chromatographic method for separating mutagens from commercial beef extract and fried ground beef. In H. F. Stitch (ed.) *Carcinogens and Mutagens in the Environment,* Vol. I, Food Products. CRC Press, Inc., pp. 223-229.

34. Hargraves, W. A. and-Pariza, M. W. 1983. Purification and mass spectral characterization of bacterial mutagens from commercial beef extract. Cancer Res. 43:1467-1472.

35. Gayda, D. P. and Pariza, M. W. 1983. Activation of 2-amino-3-methylimidazo[4,5-flquinoline and 2-aminofluorene for bacteria mutagenesis by primary monolayer cultures of adult rat hepatocytes. Mutat. Res. 118:7-14. .

36. Gayda, D. P. and Pariza, M. W. 1983. Effects of carcinogens on hormonal regulation of gene expression in primary cultures of adult rat hepatocytes. Carcinogenesis 4:1127-1131.

37. Schwartz, S. J., von Elbe, J. H., Pariza, M. W., Goldsworthy, T. J. and Pitot, H. C. 1983. Inability of red beet betalain pigments to initiate or promote hepatocarcinogenesis. Fd. Chem. Toxic. 21:531-535.

38. Pariza, M. W. 1983. Carcinogenicity/toxicity testing and the safety of foods. Food Technol. 37(1):84-86.

39. Pariza, M. W., Loretz, L. J., Storkson, J. M. and Holland, N. C. 1983. Mutagens and modulators of mutagenesis in fried ground beef. Cancer Res. 43:2444s-2446s.

40. Pariza, M. W. and Foster, E. M. 1983. Determining the safety of enzymes used in food processing. J. Food Prot. 46:453-468.

41. Pariza, M. W. 1984. A perspective on diet, nutrition, and cancer. J. Amer. Med. Assoc. 251:1455-1458 (commissioned article).

42. Loretz, L. J. and Pariza, M. W. 1984. Effect of glutathione levels, sulfate levels and metabolic inhibitors on covalent binding of 2-amino-3-methyIimidazo[4,5-flquinoline and 2-acetylaminofluorene to cell macromolecules in primary monolayer cultures of adult rat hepatocytes. Carcinogenesis 5:895-899.

43. Hargraves, W. A. and Pariza, M. W. 1984. Mutagens in cooked foods. J. Environ. Sci. Health C2(1):1-49.

44. Pariza, M. W. and Hargraves, W. A. 1985. A beef-derived mutagenesis modulator inhibits initiation of mouse epidermal tumors by 7, 12-dimethylbenz[a]anthracene. Carcinogenesis 6:591-593.

45. Pariza, M. W. 1985. Diet and cancer. American Council on Science and Health, New York, NY.

46. Pariza, M. W., Hargraves, W. A., Benjamin, H., Cristou, M., Jefcoate, C. R., Storkson, J., Albright, K., Kraus, D., Sharp, P., Boissonneault, G. A. and Elson, C. E. 1986. Modulation of carcinogenesis by dietary factors: I. Inhibition of carcinogenesis by a beef-derived mutagenesis modulator; and II. Role of net energy in enhancement of carcinogenesis by dietary fat. Environ. Health Perspectives 67:25-29.

47. Pariza, M. W., Hargraves, W. A. and Boissonneault, G. A. 1986. Modulation of carcinogenesis by a beef-derived mutagenesis modulator, and by dietary fat, In: *Genetic Toxicology of the Diet*, I. Knudsen (ed.), Alan R. Liss, Inc., pp. 265-271.

48. Boissonneault, G. A., Efson, C. E. and Pariza, M. W. 1986. Net energy effects of dietary fat on chemically-induced mammary carcinogenesis in F344 rats. JNCI 76:335-338.

49. Pariza, M. W. 1986. Analyzing current recommendations on diet, nutrition and cancer. Fd. Nutrit. News 58:1-3 (commissioned article).

50. Pariza, M. W. 1986. Calories and energy expenditure in carcinogenesis. Contemporary Nutrit. Vol. XI, No. 4 (commissioned article).

51. Pariza, M. W. 1986. Calorie restriction, ad libitum feeding, and cancer. FASEB Symposium on Nutrition and Cancer. Proc. Soc. Exptl. Biol. Med. 183:293-298.

52. Pariza, M. W. 1986. Diet and cancer: science vs policy. Pediatric Basics 44:10-15.

53. Pariza, M. W. 1986. Symposium on calories and energy expenditure in carcinogenesis-executive summary. Nutrit. Today, July/August, 21-23.

54. Poirier, L. A., P. M. Newberne, and Pariza, M. W. (eds.) 1987. *Role of Essential Nutrients in Carcinogenesis*, Plenum Press, New York, 562 pp.

55. Boissonneault, G. A., Elson, C. E. and Pariza, M. W. 1987. Dietary fat and neoplasia: The role of net energy in enhancement of carcinogenesis; Effects of fat and calories on the immune system, In: *Role of Essential Nutrients in Carcinogenesis,* L. Poirier, P. Newberne and M. Pariza (eds.), Plenum Press, New York, pp. 85-98.

56. Pariza, M. W. (Task Force Chair). 1987. Diet and health. Council for Agricultural Science and Technology, Ames, Iowa.

57. Pariza, M. W. and Boutwell, R. K. 1987. Calories and energy expenditure in carcinogenesis: Historical Perspective. Amer. J. Clin. Nutrit. (supplement) 45:151-156.

58. Pariza, M. W. 1987. Fat, calories, and mammary carcinogenesis. Amer. J. Clin. Nutrit. (supplement) 45:261-263.

59. Pariza, M. W. 1987. Dietary fat, calorie restriction, *ad libitum* feeding, and cancer risk. Nutrit. Rev. 45:1-7 (commissioned lead article).

60. Ha, Y. L., Grimm, N. K. and Pariza, M. W. 1987. Anticarcinogens from fried ground beef: Heat-altered derivatives of linoleic acid. Carcinogenesis 8:1881-1887.

61. Pariza, M. W. 1988. Effects of calorie intake and expenditure on carcinogenesis, In: *Horticulture and Human Health. Contributions of Fruits and Vegetables.* Proc. 1st Int. Symp. Horticulture and Human Health. B. Quebedeaux and F. A. Bliss (eds.), Prentice-Hall, Englewood Cliffs, N.J., pp. 144-149.

62. Pariza, M. W. 1988. Dietary fat and cancer risk: Evidence and research needs. Ann. Rev. Nutr. 8:167-183.

63. Benjamin, H., Storkson, J., Tallas, P. G., and Pariza, M. W. 1988. Reduction of benzo (a) pyrene-induced forestomach neoplasms in mice given nitrite and dietary soy sauce. Fd. Chem. Toxicol. 26:671-678.

64. Ha, Y. L., Grimm, N. K., and Pariza, M. W. 1989. Newly recognized anticarcinogenic fatty acids: Identification and quantification in natural and processed cheeses. J. Ag. Fd. Chem. 37:75-81.

65. Johnson, E. A. and M. W. Pariza. 1989. Microbiological principles for the safety of foods, In: *International Food Regulation Handbook. Policy, Science, Law.* R. D. Middlekauff and P. Shubik (eds.), Marcel Dekker, Inc., New York, pp. 135-174.

66. Pariza, M. W. 1989. A perspective on diet and cancer, In: *Food Toxicology. A Perspective on Relative Risks.* S. L. Taylor and R. A. Scanlan (eds.) Marcel Dekker, Inc., New York, pp. l-10.

67. Ha, Y. L., Storkson, J. and Pariza, M. W. 1990. Inhibition of benzo (∝) pyrene-induced mouse forestomach neoplasia by conjugated dienoic derivatives of linoleic acid. Cancer Res. 50:1097-1101.

68. Pariza, M. W. and Ha, Y. L. 1990. Newly recognized anticarcinogenic fatty acids, In: *Antimutagenesis and Anticarcinoglenesis Mechanisms II.* Y. Kuroda, D. M. Shankel and M. D. Waters (eds.) Plenum Press, New York, pp. 167-170.

69. Pariza, M. W., Aeschbacher, H.-U., Felton, J. S. and Sato, S., Eds. 1990. *Mutagens and Carcinogens in the Diet,* Wiley-Liss, Inc., New York, 332 pp.

70. Pariza, M. W. and Ha, Y. L. 1990. Conjugated dienoic derivatives of linoleic acid: Mechanism of anticarcinogenic effect, In: *Mutagens and Carcinogens in the Diet.* Pariza, M. W., Aeschbacher, H.-U., Felton, J. S. and Sato, S. (eds.) Wiley-Liss, Inc., New York, pp. 217-221.

71. Pariza, M. W., and Ha, Y. L. 1990. Conjugated dienoic derivatives of linoleic acid: a new class of anticarcinogens. Medical Oncology Tumor Pharmacology. 7:169-172.

72. Pariza, M. W. 1990. Diet and cancer, In: *Foodborne Diseases.* Cliver, D. O. (ed.) Academic Press, Inc., New York, New York, pp. 308-317.

73. Pariza, M. W. 1990. Perspectives on food safety and biotechnology, In: *Biotechnology and Food Safety,* Proceedings of the Second International Symposium. Bills, D. D. and Kung, S. D. (eds.) Butterworth-Heinemann, Boston, pp. 47-52.

74. Ha, Y. L., and Pariza, M. W. 1990. Anticarcinogenic conjugated dienoic derivatives of linoleic acid found in grilled ground beef: Isolation, identification, and mechanism of action, In: *The First Korean Conference on Science and Technology.* The Korean Federation and Science Association, Seoul, Korea, pp. 442-445.

75. Pariza, M. W. 1990. Evaluating the relative safety of biotechnologically produced foods. In: *Agricultural Biotechnology. Food Safety and Nutritional Quality for the Consumer,* NABC Report 2. Union Press of Binghampton, New York, pp. 167-173.

76. Benjamin, H., Storkson, J., Nagahara, A. and Pariza, M. W. 1991. Inhibition of benzo[a]pyrene-induced. mouse forestomach neoplasia by dietary soy sauce. Cancer Res. 51:2940-2942.

77. Pariza, M. W. 1991. CLA, a new cancer inhibitor in dairy products. Bull. Int. Dairy Fed. 257:29-30.

78. Pariza, M. W. and Ha, Y. 1991. Fatty acids that inhibit cancer: Conjugated dienoic derivatives of linoleic acid. In: *Nutrients and Cancer Prevention,* K. N. Prasad and F. L. Meyskens, Jr., eds. Humana Press, Clifton, NJ, pp. 113-117.

79. Pariza, M. W., Ha, Y. L., Benjamin, H., Sword, J. T., Grüter, A., Chin, S. F., Storkson, J., Faith, N., and Albright, K. 1991. Formation and action of anticarcinogenic fatty acids. In: *Nutritional and Toxicological Consequences of Food Processing,* M. Friedman, ed. Plenum Publishing Corp., New York, New York, pp. 269-272.

80. Pariza, M. W. 1991. Human health concerns associated with pesticidal transgenic plants. In: PesticidaI Transgenic Plants: Product Development, Risk Assessment, and Data Needs. U. S. EPA Conference Proceedings. Document #EPA/21T-1024, pp. 107-111.

81. Ip, C., Chin, S. F., Scimeca, J. A., and Pariza, M. W. 1991. Mammary cancer prevention by conjugated dienoic derivatives of linoleic acid. Cancer Res. 51:6118-6124.

82. Pariza, M. W. 1992. A new approach to evaluating carcinogenic risk. Proc. Natl. Acad. Sci. U.S.A. 89:860-861.

83. Pariza, M. W. 1992. Risk assessment. Crit. Rev. Food Sci. Nutr. 31:205-209.

84. Pariza, M. W. 1992. Risk-benefit perceptions. Chapter 4 in *Food Safety Assessment*, J. W. Finley, S. F. Robinson, and D. J. Armstrong, (eds.) American Chemical Society, Washington, DC, pp. 36-40.

85. Nagahara, A., Benjamin, H., Storkson, J., Krewson, J., Sheng, K., Liu, W., and Pariza, M. W. 1992. Inhibition of benzo[a]pyrene-induced mouse forestomach neoplasia by a principal flavor component of Japanese-style fermented soy sauce. Cancer Res. 52:1754-1756.

86. Pariza, M. W. 1992. Foods of new biotechnology vs traditional products: microbiological aspects. Food Technol. 46(3):100-102.

87. Pariza, M. W. 1992. Designer foods: effects on development of cancer. J.N.C.I. Mono. 12:105-107.

88. Pariza, M. W. 1992. Chemoprevention by conjugated dienoic isomers of linoleic acid. In: *Cancer Chemoprevention,* L. Wattenberg, M. Lipkin, C. W. Boone and G. J. Kelloff (eds.) CRC Press, Inc., Boca Raton, FL, pp. 279-283.

89. Chin, S. F., Liu, W., Storkson, J. M., Ha, Y. L. and Pariza, M. W. 1992. Dietary sources of conjugated dienoic isomers of linoleic acid, a newly recognized class of anticarcinogens. J. Food Comp. Anal. 5:185-197.

90. Foster, E. M. and Pariza, M. W. 1993. Food safety: federal inspection programs. Commissioned by the Council on Scientific Affairs, American Medical Association. Arch. Fam. Med. 2:210-214.

91. Cook, M. E., Miller, C. C., Park, Y. and Pariza, M. W. 1993. Immune modulation by altered nutritient metabolism: nutritional control of immune-induced growth depression. Poultry Sci. 72:1301-1305.

92. Parriza, M. W. 1993. Diet and cancer: where do matters stand? Commissioned by the Council on Scientific Affairs, American Medical Association, Chicago, IL. Arch. Intern. Med. 153:50-56.

93. Chin, S. F., Storkson, J. M., and Pariza, M. W. 1993. Conjugated dienoic derivatives of linoleic acid. Chapter 21. In: *Food Flavor and Safety: Molecular Analysis and Design,* A. M. Spanier, H. Okai, and M. Tamura, (eds.) American Chemical Society, Washington, DC, pp. 262-271.

94. Pariza, M. W. 1993. Chapter 88: Diet, cancer, and food safety. In: *Modern Nutrition in Health and Disease,* 8th Edition. M. E. Shils, J. A. Olson, and M. Shike (eds.) Lea and Febiger, Philadelphia, pp. 1545-1558.

95. Pariza, M. W. 1993. CLA and HEMF: newly recognized anticarcinogenic antioxidants. In *Active Oxygens, Lipid Peroxides, and Antioxidants,* K. Yagi (ed.) Japan Sci. Sot. Press, Tokyo/CRC Press, Boca Raton, FL, pp. 359-365.

96. Pariza, M. W. 1994. Chapter 28. Fermentation-derived anticarcinogenic flavor compound. In: *Food Phytochemicals for Cancer Prevention I,* American Chemical Society Symposium Series 546, M. T. Huang, T. Osawa, C. T. Ho, and R. T. Rosen (eds.) American Chemical Society, Washington, DC, pp. 349-352.

97. Bonorden, W. R. and Pariza, M. W. 1994. Antioxidant nutrients and protection from free radicals. In: *Nutritional Toxicology* Target Organ Toxicology Series, F. N. Kotsonis, M. Mackey, and J. J. Hjelle (eds.) Raven Press, Ltd., New York, pp. 19-48.

98. Miller, C. C., Park, Y., Pariza, M. W., and Cook, M. E. 1994. Feeding conjugated linoleic acid to animals partially overcomes catabolic responses due to endotoxin injection. Biochem. Biophys. Res. Commun. 198:1107-1112.

99. Lee, K. N., Kritchevsky, D., and Pariza, M. W. 1994. Conjugated linoleic acid and atherosclerosis in rabbits. Atherosclerosis 108:19-25.

100. Chin, S. F., Storkson, J. M., Liu, W., Albright, K. J., and Pariza, M. W. 1994. Conjugated linoleic acid (9, 11- and 10, 12-octadecadienoic acid) is produced in conventional but not germ-free rats fed linoleic acid, J. Nutr. 124:694-701.

101. Chin, S. F., Storkson, J. M., Albright, K. J., Cook, M. E., and Pariza, M. W. 1994. Conjugated linoleic acid is a growth factor for rats as shown by enhanced weight gain and improved feed efficiency. J. Nutr. 124:2344-2349.

102. Yurawecz, M. P., Hood, J. K., Roach, J. A. G., Mossoba, M. M., Daniels, D. H., Ku, Y., Pariza, M. W. and Chin, S. F. 1994. Conversion of allylic hydroxy oleate to conjugated linoleic acid and methoxy oleate by acid-catalyzed methylation procedures. JAOCS 71(10):1149-1155.

103. Conn, R. E., Kolstad, J. J., Borzelleca, J. F., Dixler, D. S., Filer Jr., L. J., LaDu, Jr., B. N., and Pariza, M. W. 1995. Safety assessment of polylactide (PLA) for use as a food-contact polymer. Fd. Chem. Toxic. 33(4):273-283.

104. Cohen, S. M., Clydesdale, F. M., Winter, C., Graham, J. D., Weil Jr., W. B., Kroger, M., Pariza, M. W., Crawford, L. M., Avery, D., Scheuplein, R. J. and Weisberger, E. 1995. Delaney Reform. (Letter.) Science 268:1829-1830.

105. Liew, C., Schut, H. A. J., Chin, S. F., Pariza, M. W. and Dashwood, R. H. 1995. Protection of conjugated linoleic acids against 2-amino-3-methylimidazo [4,5-*f*]quinoline-induced colon carcinogenesis in the F344 rat: a study of inhibitory mechanisms. Carcinogenesis 16:3037- 3043.

CURRICULUM VITAE

WILLIAM HOWARD GLAZE

Professor and Chair
Department of Environmental Sciences & Engineering
School of Public Health
University of North Carolina at Chapel Hill
106 Rosenau Hall/Campus Box 7400
Chapel Hill, NC 27599-7400
tel: 919-966-1024
fax: 919-966-2583
email: *bill_glaze @ unc.edu*

Social Security #452-40-2299
Date/Place of birth: November 21, 1934 Sherman, Texas

EDUCATIONAL DATA

B.S. Southwestern University, Georgetown, Texas - 1956

M.S. University of Wisconsin, Madison - 1958 (Physical/polymer chemistry)

Ph.D. University of Wisconsin, Madison - 1961 (Physical chemistry)

Post-doctoral Fellowship - Robert A. Welch Foundation
Fellowship at Rice University, Houston, Texas - 1961

PROFESSIONAL EXPERIENCE

The University of North Carolina, Chapel Hill: Professor and Chair, Department of Environmental Sciences and Engineering, School of Public Health, July, 1989 - present

The University of California, Los Angeles: Professor, Division of Environmental & Occupational Health Sciences: School of Public Health; Director, Environmental Science & Engineering Program, 1984-89.

The University of Texas at Dallas: Professor of Environmental Sciences and Chemistry; Head, Graduate Program in Environmental Sciences; Director, Center for Energy and Environmental Studies, September, 1980-84.

North Texas State University: Assistant Professor, 1961-63; Associate Professor, 1963- 65; Professor of Chemistry, 1965-80; Associate Dean, College of Arts and Sciences, 1973-75; Director, Institute of Applied Science, 1973-80.

HONORS AND AWARDS

Outstanding Teaching Award, 1973;
Distinguished Teaching Award of the Alumni Association, North Texas State University, 1975;
Citation of Merit Award, Southwestern University, 1974;
Analyst of the Year Award, Dallas Society of Analytical Chemists, 1979;
F.J. Zimmerman Award in Environmental Sciences, 1986;
Harvey Rosen Award, International Ozone Association, 1989;
Honorary Doctors of Science, Southwestern University, 1990;
Donald R. Boyd Award by the Association of Metropolitan Water Agencies, 1991.

EDITORIAL DUTIES

Environmental Science and Technology, 1980-1986; Editor, 1988-present.

Chemical Research in Toxicology, Editorial Advisory Board, 1992-present.

RECENT PROFESSIONAL ACTIVITIES

Member: American Chemical Society, American Institute of Chemical Engineers, American Water Works Association, Society of Environmental Chemistry and Toxicology;

Chairman: Committee on Water Treatment Chemicals, National Research Council, National Academy of Sciences, 1980-85.

Member: Safe-Drinking Water Sub-committee on Health Effects of Disinfection By-product, National Research Council, 1985-87.

Member: Peer Review Group, Health Risks of Drinking Water Treatment Additives, National Sanitation Foundation, 1986-87.

Member: EPA Science Advisory Board, Environmental Engineering Committee and Drinking Water Sub-Committee, 1987-89;

Chairman: SAB Committee on Drinking Water, 1989-91;

Member: Global Climate Change Research, Development and Assessment Advisory Panel, Argonne National Laboratory, 1992.

CURRENT CONTRACTS AND GRANTS

Los Alamos National Laboratory, "Research and Study of Photodegradation of Organics in Mixed Waste," 1993-95.

Army Corps of Engineers, "Identification of By-Products Formed in the Treatment of Munitions Waste Compounds by Advanced Oxidation Processes," 1994-97.

Army Environmental Policy Institute, "An Assessment of Industrial Wastewater Treatment with Advanced Oxidation Processes Technologies," 1993-95.

American Water Works Association Research Foundation, "Analytical Methods for Polymers, Associated Contaminants, and Oxidative By-Products," 1993-95 (with H. Weinberg).

PEER REVIEWED PUBLICATIONS

1. "Solid Complexes of Alkyllithium Compounds with Lithium Halides," W.H. Glaze, R. West, *J. Amer. Chem. Soc.,* **82,** 4437 (1960).

2. "The Infrared Spectra .of Alkyllithium Compounds," R. West, W.H. Glaze, *J. Amer. Chem. Soc.,* **83,** 3580 (1961).

3. "Direct Preparation of Vinyllithium," R. West, W.H. Glaze, *J. Org. Chem.,* **26,** 2096 (1961).

4. "Lithium Kinetic Isotope Effect in the Reaction of Ethyllithium with Benzyl Chloride," R. West, W.H. Glaze, *J. Chem. Phys.,* **34,** 685 (1961).

5. "Evidence from Intrinsic Viscosity and Sedimentation for Hypercoiled Configurations of Styrene-Maleic Acid Copolymer," W. Dannhauser, W.H. Glaze, R.L. Dueltgen, K. Nimomyiya, *J. Phys. Chem.,* **65,** 954 (1960).

6. "The Thermal Decomposition of sec-Butyllithium," W.H. Glaze, J. Lin, E.G. Felton, *J. Org. Chem.,* **30,** 248 (1966).

7. "Pyrolysis of Unsolvated Alkyllithiums," W.H. Glaze, J. Lin, E.G. Felton, *J. Org. Chem.,* **30,** 248 (1966).

8. "Pyrolysis of sec-Butyllithium: Kinetics and Mechanism," W.H. Glaze, G.M. Adams, *J. Amer. Chem. Soc.,* **88,** 4653 (1966).

9. "The Preparation and Properties of Organomagnesium Compounds in Benzene Solvent. I. n-Amylmagnesium Compounds," W.H. Glaze, C.M. Selman, *J. Organometal. Chem.,* **5,** 477 (1966).

10. "Di-n-Butylberyllium: A Novel Preparative Method," W.H. Glaze, C.M. Selman, C.H. Freeman, *Chem. Comm.,* 474 (1966).

11. "Some (L-Aminoacido) triethylenetetraaminecobalt (III) Iodides," W.H. Glaze, B.E. Bryant, J. Hu, *Inorg. Chem.,* **5,** 1373 (1966).

12. "Cyclohexylmetal Compounds I. 4-t-Butylcyclohexyllithium," W.H. Glaze, C.M. Selman, *J. Organometal. Chem.,* **11,** 3 (1968).

13. "Cyclohexylmetal Compounds II. Nuclear Magnetic Resonance and Carbonation Results of (+)-Methyllithium," W.H. Glaze, C.M. Selman, *J. Org. Chem.,* **33,** 1987 (1968).

14. "Gas Chromatographic Studies on Taste and Odor in Water," J.K.G. Silvey, W.H. Glaze, A.H. Hendricks, D. Henley, *J. Amer. Water Works Assn.* , **60,** 440 (1968).

15. "Organolithiums. Annual survey covering the year 1967," W.H. Glaze, *Organometal. Chem. Rev.* , Sect. B, **4,** 161 (1968).

16. "4-tert-Butylcyclohexyllithium," W.H. Glaze, *J. Organometal. Chem* , **11,** P3-P4 (1968).

17. "Organosodiums and organopotassiums. Annual survey covering the year 1967," W.H. Glaze, *Organometal. Chem. Rev,* Sect. B, **4,** 189 (1968).

18. "Isolation and identification of an odor compound produced by a selected aquatic actinomycete," W.H. Glaze, D.E. Henley, J.K.G. Silvey, *Amer. Chem. Soc., Div. Water, Air Waste Chem., Gen. Pap.,* **8,** 61 (1968).

19. "Cyclohexylmetal Compounds III. Stereochemistry of Some Substitution Reactions at the Carbon-Lithium Bond," W.H. Glaze, C.M. Selman, L. Ball, L. Bray, *J. Org. Chem.,* **34,** 641 (1969).

20. "Isolation and Identification of an Odor Compound from a Selected Aquatic Actinomycete," J.K.G. Silvey, W.H. Glaze, D. Henley, *Environ. Sci. & Technol.,* **3,**268 (1969).

21. "Organometallic Photochemistry I. The Photolysis of Ethyllithium," W.H. Glaze, T.L. Brewer, *J. Amer. Chem.* Soc. , **91**, 4490 (1969).

22. "Cyclohexylmetal Compounds IV. Effect of Aggregate Size on the Reactivity of Alkyllithium Compounds," W.H. Glaze, C.H. Freeman, *J. Amer. Chem. Soc.* , **91,** 7198 (1969).

23. "Allythium Compounds from Buta-1,3-diene and s- or t-Butyllithium," W.H. Glaze, P.C. Jones, *Chem. Comm.,* 1434 (1969).

24. "Lithium. Annual Survey Covering the Year 1968," W.H. Glaze, *Organometal. Chem. Rev.,* Sect. B, **5,** 213 (1969).

25. "Sodium and Potassium. Annual Survey Covering the Year 1968," W.H. Glaze, *Organometal. Chem Rev.*, Sect. B, **5,** 213 (1969).

26. "Bonding Properties in Organolithium Aggregates," W.H. Glaze, G.R. Peyton, *Theor. Chim. Acta* , **13,** 259 (1969).

27. "Allyllithium Adducts from 1,3-Butadiene and sec- or tert-Butyllithium," W.H. Glaze, P.C. Jones, *J. Chem. Soc.* D **23,** 1434 (1969).

28. "Organometallic Photochemistry II. Evidence for 1, 1 Bisdiethylaluminoethane from the Photolysis of Triethylaluminum," W.H. Glaze, T.L. Brewer, A.C. Ranade, *J. Organometal. Chem.,* **25,** C3 (1970).

29. "Sodium and Potassium. Annual Survey Covering the Year 1969," W.H. Glaze, *Organometal. Chem. Rev.* , Sect. B, **6,** 61 (1970).

30. "Lithium. Annual Survey Covering the Year," W.H. Glaze, *Organometal. Chem. Rev.*, Sect. B, **6,** 1 (1970).

31. "Organometallic Photochemistry III. The Photolysis of O-Annisyllithium," W.H. Glaze, A.C. Ranade, *J. Org. Chem.,* **36,** 3331 (1971).

32. "Lithium. Annual Survey Covering the Year 1970," W.H. Glaze, *Organometal. Chem. Rev.,* Sect. B, **8,** 253 (1971).

33. "Sodium and Potassium. Annual Survey Covering the Year 1970," W.H. Glaze, *Organometal. Chem. Rev. ,* Sect. B **8,** 319 (1971).

34. "Neopentylallyllithium I. The 1, 4-Addition Product of 1, 3-Butadiene and t-Butyllithium," W.H. Glaze, J.E. Hanicak, J. Chaudhuri, M.L. Moore, *J. Organometal. Chem.,* **44,** 39 (1972).

35. "Neopentylallyllithium II. Reactions in Hydrocarbon Media," W.H. Glaze, J.E. Hanicak, D.J. Berry, D.P. Duncan, *J. Organometal Chem.,* **44,** 49 (1972).

36. "Neopentylallyllithium III. PRM and UV Spectra in Ether Solvents," W.H. Glaze, J.E. Hanicak, J. Chaudhuri, M.L. Moore, D.P. Duncan, *J. Organometal. Chem.*, **51,** 13 (1973).

37. "Neopentylallyllithium IV. Reactions in Ether Solvent," W.H. Glaze, J.E. Hanicak, D.J. Berry, D.P. Duncan, *J. Organometal. Chem.,* **52,** 233 (1973).

38. "Bis(neopentylallyl)magnesium," W.H. Glaze, C.R. McDaniel, *J. Organometal. Chem.,* **51,** 23 (1973).

39. "Analysis of Organic Materials in Wastewater After Chlorination," W.H. Glaze, J.E. Henderson IV, J. Bell, V. Wheeler, *J. Chromatographic Science,* **11,** 580 (1973).

40. "Lithium. Annual Survey Covering the Year 1971," W.H. Glaze, *J. Organometal. Chem.,* **48,** 1 (1973).

41. "Sodium and Potassium. Annual Survey for the Year 1971," W.H. Glaze, *J. Organometal. Chem.,* **48,** 65 (1973).

42. "Sodium and Potassium. Annual Survey for the Year 1972," W.H. Glaze, *J. Organometal. Chem.,* **62,** 1 (1973).

43. "Lithium. Annual Survey Covering the Year 1972," W.H. Glaze, *J. Organometal. Chem,* **68,** 1 (1974).

44. "Formation of Organochlorine Compounds from the Chlorination of Municipal Secondary Effluents," W.H. Glaze, J.E. Henderson IV, *Journal of the Water Pollution Control Federation,* **10,** pp. 2511-2515 (1975).

45. "Neopentylallylsodium," W.H. Glaze, D.P. Duncan, *J. Organometal. Chem.,* **99,** pp. 11-21 (1975).

46. "Neopentylallyllithium V. Stereochemistry of Nonrearrangement Reactions with Epoxides," W.H. Glaze, D.P. Duncan, D.J. Berry, *J. Organic Chem.,* **42,** 594 (1977).

47. "Addition of t-Butyllithium to Dienes of Fixed Conformation," W.H. Glaze, R.B. Reinarz, M.L. Moore, *J. Polymer Sci. ,* Part B **15,** pp. 141-145 (1977).

48. "Total Organic Halogen as a Water Quality Parameter: An Adsorption/ Microcoulometric Method," W.H. Glaze, G.R. Peyton, R. Rawley, *Environ. Sci. & Technol.* , **11,** pp. 685-690 (1977).

49. "Chlorinated Tyrosine in Municipal Waste Treatment Plant Products after Superchlorination," W.H. Glaze, J.L. Burleson, G.R. Peyton, *Bulletin of Envir. Cont. Amer. and Toxico.,* **19,** pp. 724-728 (1978).

50. "A Preliminary Survey of Trihalomethanes (THM) Levels in Selected East Texas Water Supplies," W.H. Glaze, R. Rawley, *J. Amer. Water Works Assoc.,* **71,** pp. 509-515 (1979).

51. "Analysis of Disinfection By-Products in Water and Wastewater," W.H. Glaze, G.R. Peyton, F.Y. Saleh, F. Huang, *Int. J. Environ. Anal. Chem.,* **7,** pp. 143-160 (1979).

52. "Characterization of Nonvolatile Halogenated Compounds Formed During Water Chlorination," W.H. Glaze, *Water Chlorination: Environ. Impact Health Eff.,* **3,**99 (1980).

53. "Gas Chromatographic/Mass Spectrometric Analysis of Derivatized Amino Acids in Municipal Wastewater Products," J.L. Burleson, G.R. Peyton, W.H. Glaze, *Environ. Sci. & Technol.,* **14,** 1354-1360 (1980).

54. "GC/MS Analysis of XAD-2 Extracts of Superchlorinated Septage," J.E. Henderson, W.H. Glaze, *Water Research,* **16,** pp. 211-218 (1982).

55. "Destruction of Pollutants in Water with Ozone in Combination with Ultraviolet Radiation 1. General Principles and Oxidation of Tetrachloroethylene," G.R. Peyton, F.Y. Huang, J.L. Burleson, W.H. Glaze, *Environ. Sci. & Technol.,* **16,** pp. 448-453 (1982).

56. "Destruction of Pollutants in Water with Ozone and Ultraviolet Radiation 2. Natural THM Precursors," W.H. Glaze, G.R. Peyton, S. Lin, R.Y. Huang, J.L. Burleson, *Environ. Sci. Tech.*, **16**, pp. 454-458 (1982).

57. "Pilot Scale Evaluation of Ozone-Granular Activated Carbon Combinations for Trihalomethane Precursor Removal," W.H. Glaze, J.L. Wallace, D. Wilcox, K.R. Johansson, D.L. Dickson, B. Sclaf, R. Noack, A.W. Busch, *Adv. Chem. Ser*, **202** (Treat. Water Granular Act. Carbon), 303 (1983).

58. "Control of Trihalomethane Precursors in Drinking Water: Granular Activated Carbon With and Without Preozonation," W.H. Glaze, J.L. Wallace, *J. Amer. Water Works Assoc.,* **2**, pp. 68-75 (1984).

59. "Fate of Naphthalene in a Rotating Disc Biological Contactor," W.H. Glaze, G.R. Peyton, C.F. Young, C.C. Lin, *J. Water Pollution Control Assoc.*, **58**, pp. 792-798 (1986).

60. "Adsorption and Microbiological Mechanisms for Removal of Natural Organics in Granular Activated Carbon Columns," W.H. Glaze, C.C. Lin, J.C. Crittenden, and R. Cotton, *Ozone: Sci. & Eng.,* **8**, pp. 299-319 (1986).

61. "The Chemistry of Water Treatment & Processes Involving Ozone, Hydrogen Peroxide and Ultraviolet Radiation," W.H. Glaze, J.W. Kang, and D.H. Chapin, *Ozone: Sci. & Eng.,* **9**, pp. 335-352 (1987).

62. "Drinking-Water Treatment with Ozone,"W.H. Glaze, *Environ. Sci. & Technol.,* **21**, 224 (1987).

63. "Advanced Oxidation Processes for Treating Groundwater Contaminated With TCE and PCE: Laboratory Studies," W.H. Glaze, J.W. Kang, *J. Amer. Water Works Assoc.,* **80**, pp. 57-63 (1988).

64. "Advanced Oxidation Processes for Treating Groundwater Contaminated With TCE and PCE: Pilot-Scale Evaluations," E.M. Aieta, KM. Reagan, J.S. Lang, L. McReynolds, J.W. Kang, W.H. Glaze, *J. Amer. Water Works Assoc ,* **80**, pp. 64-72. (1988).

65. "Destruction of Pollutants in Water with Ozone in Combination with Ultraviolet Radiation," W.H. Glaze, G.R. Peyton, *Environ. Sci. & Technol.,* **22**, pp. 761-767 (1988).

66. "Ozonation By-Products 2. Improvement of an Aqueous Phase Derivatization Method for the Detection of formaldehyde and Other Carbonyl Compounds Formed by the Ozonation of Drinking Water," W.H. Glaze, M. Koga, D. Cancilla, *Environ. Sci. & Technol.* **23**, pp. 838- 847 (1989).

67. "Ozonation By-Products 3. Evaluation of Ozone By-Products from Two California Surface Waters," W.H. Glaze, M. Koga, D. Cancilla, K.Wang, M.J. McGuire, S. Liang, M.K. Davis, C.H. Tate, E.M. Aieta, *J. Amer. Water Works Assoc.*, **81**,
pp. 66-73 (1989).

68 . "Advanced Oxidation Processes. Description of a Kinetic Model for the Oxidation of Hazardous Materials in Aqueous Media With Ozone and Hydrogen Peroxide in a Semi-Batch Reactor," W.H. Glaze, J. Kang, *Indus. & Engng. Chem. Res.*, **28**, 1573 (1989).

69. "Advanced Oxidation Processes. Test of a Kinetic Model for the Oxidation of Hazardous Materials in Aqueous Media With Ozone and Hydrogen Peroxide in a Semi-Batch Reactor," W.H. Glaze, J. Kang, *Indus . & Engng. Chem. Res.*, **28**, 1580 (1989).

70. "Evaluation of Ozonation By-Products from Two California Surface Waters," W.H. Glaze, M. Koga, D. Cancilla, K. Wang, M.J. McGuire, S. Liang, M.K. Davis, C.H. Tate, E.M. Aieta, *J. Amer. Water Works Assoc.* **81**, 66 (1989).

71. "Evaluating Oxidants for Removal of Model Taste and Odor Compounds," W.H. Glaze, R. Schep, W. Chauncey, E.C. Ruth, J.J. Zarnoch, E.M. Aieta, C.H. Tate, M.J. McGuire, *J . Amer. Water Works Assoc.*, **82**, 79 (1990).

72. "Binational Management of Hazardous Waste: The Maquiladora Industry at the U.S.-Mexico Border," D.M. Perry, R. Sanchez, W.H. Glaze, M. Mazari, *Environ. Management,* **14**, pp. 441-450 (1990).

73. "The 'Big Switch': Los Angeles Aqueduct Filtration Plant Treatment of California State Project Water," S. Liang, G.F. Stolarik, C.H. Tate, W.H. Glaze, *Ozone: Sci. & Eng.,* **13**(6), pp. 711-731 (1991).

74. "Analysis of Ozonation By-Products Produced in Drinking Water Treatment," M. Koga, T. Akiyama, W.H. Glaze, *Toxicol. Ind. Health,* **7**, 423 (1991).

75. "Characterization of Natural Water for Potential to Oxidize Organic Pollutants with Ozone," S. Guittonneau, W.H. Glaze, J.P. Duguet, O. Wable, J. Mallevialle, *Ozone: Sci. & Eng.,* **14**(3), pp. 185-196 (1992).

76. "Ozonation By-Products. Identification of Bromohydrins from the Ozonation of Natural Waters with Enhanced Bromide Levels," J.E. Cavanagh, H.S. Weinberg,

A. Gold, R. Sangaiah, D. Marbury, W.H. Glaze, T.W. Collette, S. Richardson, A.D. Thruston, *Environ. Sci. & Technol.* **26**(8), pp. 1658-1662 (1992).

77. "Chemical Models of Advanced Oxidation Processes," W.H. Glaze, F. Beltran, T. Tuhkanen, J.W. Kang, *Water Pollution Research Journal of Canada,* **27**(1), 23-42 (1992).

78. "Chlorinated By-Products from the TiO_2-Mediated Photodegradation of Tetrachloro-ethylene and Trichloroethylene in Water," W.H. Glaze, J.F. Kenneke, J.L. Ferry, *Environ. Sci. & Technol.,* **27**, pp. 177-184 (1993).

79. "Formation and Control of Bromate During Ozonation of Waters Containing Bromide," S. W. Krasner, W.H. Glaze, H.S. Weinberg, P.A. Daniel, I.N. Najm, *J. Amer. Water Works Assoc.*, **85**, pp. 73-81 (1993).

80. "Evaluating the Formation of Brominated DBPs During Ozonation," W.H. Glaze, H.S. Weinberg, J.E. Cavanagh, *J. Amer. Water Works Assoc.*, **85**, pp. 96-103 (1993).

81. "Determining Health Risks Associated with Disinfectants and Disinfection By-Products: Research Needs," W.H. Glaze, J.B. Andelman, R.J. Bull, R.B. Conolly, C.D. Hertz, R.D. Hood and R.A. Pegram, *J. Amer. ,Water Works Assoc.,* **85**, pp. 53-56 (1993).

82. "Formation and Removal of Aldehydes in Plants that use Ozonation," H.S. Weinberg, W.H. Glaze, S.W. Krasner, M.J. Sclimenti, *J. Amer. Water Works Assoc.,* **85**, 72 (1993).

83. "The Titanium Dioxide-Mediated Photocatalytic Degradation of Chloroalkenes in Water," J.F. Kenneke, J.L. Ferry, W.H. Glaze, *Trace Metals in the Environment,* Vo13, Photocatalytic Purification and Treatment of Water and Air, D. F. Ollis and H. Al-Ekabi, eds., Elsevier, New York, p. 179 (1993).

84. "Training the Next Generation of Environmental Professionals: Problems at the Academy," W.H. Glaze, *Water Resources,* **94**, pp. 78-80 (1994).

85. 'An Overview of Advanced Oxidation Processes: Current Status and Kinetic Models," W.H. Glaze, *Chem. Oxid.,* Volume Date 1993, **3**, 1 (1994).

86. "The Reaction of Ozone and Hydroxyl Radicals with Serine," R.M. Le Lacheur, W.H. Glaze, *Environ. Sci. & Technol.,* in press (1995).

87. "Advanced Oxidation Processes: A Kinetic Model for the Oxidation of 1, 2-Dibromo-3- chloropropane in Water by the Combination of Hydrogen Peroxide and UV Radiation," W.H. Glaze, Y. Lay, J.W. Kang, *Indus. Eng. Chem. Res.,* 1995, **34**, 2314-2323.

88. "Advanced Oxidation Processes: The Interplay of Oxidation and Direct Photolysis of Naphthalene and Pentachlorophenol in the Hydrogen Peroxide/UV Process," W.H. Glaze, F.J. Beltran, T. Tuhkanen, *Ozone: Sci. & Eng.* (in press).

CONFERENCE PROCEEDINGS

1. "Pyrolysis of Alkyllithium Compounds," W.H. Glaze, T.L. Brewer, R. Hatch, J. Nathan, *Decomposition of Organometallic Compounds to Refractory Ceramics, Metals, and Metal Alloys,* University of Dayton Press, Dayton, Ohio (1968), pp. 187-194.

2. "A Convenient Liquid-Liquid Extraction Method for the Determination of Halomethanes in Water at the Parts-per-Billion Level," J.E. Henderson IV, G.R. Peyton, W.H. Glaze, *Identification and Analysis of Organic Pollutants in Water*, L.H. Keith, ed., Ann Arbor Science, Publishers, Inc., Ann Arbor, Michigan, pp. 105-l12 (1976).

3. "Analysis of New Chlorinated Organic Compounds Formed by Chlorination of Municipal Wastewater," W.H. Glaze, J.E. Henderson, IV, Garmon Smith, in *Water Chlorination: Environmental Impact and Health Effects,* Vol. 1, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan, pp. 139-159 (1978).

4. "By-Products of Organic Compounds in the Presence of Ozone and Ultraviolet Radiation," W.H. Glaze, R. Rawley, S. Lin, *Ozone/Chlorine Dioxide Oxidation Products of Organic Materials, Ozone Press* International, Cleveland, Ohio, pp. 321-331 (1978).

5. "Soluble Organic Constituents of Natural Waters and Wastewaters Before and After Chlorination," W.H. Glaze, G.R. Peyton, *Water Chlorination: Environmental Impact and Health Effects,* R.L. Jolley, H. Gorchev, D.H. Hamilton, Jr., eds., Ann Arbor Science Publishers, Ann Arbor, Michigan, pp. 3-14 (1978).

6. "Characterization of Non-Volatile Halogenated Compounds Formed During Water Chlorination," in *Water Chlorination: Environmental Impact and Health Efsects*, R.L. Jolley, W.A. Brungs, R.B. Cumming, eds., Ann Arbor Science Publishers, Ann Arbor, Michigan, pp. 99-108 (1980).

7. "Size Exclusion, Reverse-Phase and Weak Anion Exchange Chromatography of Natural Organics in Water," W.H. Glaze, P.C. Jones, F.W. Saleh, in *Advances in the Identification and Analysis of Organic Pollutants in Water*, L.H. Keith, ed., Ann Arbor Science Publishers, Ann Arbor, Michigan, Volume 1, pp. 371-382 (1981).

8. "Further Optimization of the LLE Method for the Analysis of Trace Organic Compounds in Water," W.H. Glaze, R. Rawley, J.L. Burleson, D. Mapel, D.R. Scott, in *Advances in the Identification and Analysis of Organic Pollutants in Water*, L.H. Keith, ed., Ann Arbor Science Publishers, Ann Arbor, Michigan, pp. 37 l-382 (1981).

9. "Effects of Ozone on GAC Removal of THM Precursors," W.H. Glaze, J.L. Wallace, D. Wilcox, K.R. Johansson, K.L. Dickson, B. Scalf, R. Noack, A.W. *Busch, Wasser Berlin '81,* IOA International Ozone Association, 5th Ozon-Weltkongress, Berlin, 1981; Colloquium Verlag Otto H. Hess, Berlin (1981), pp. 485-497.

10. "Pilot Scale Evaluation of Ozone/GAG Combinations for THM Precursor Removal," W.H. Glaze, J.L. Wallace, D. Wilcox, K.R. Johansson, K.L. Dickson, B. Scalf, R. Noack, A.W. Busch, in Advances in Chemistry Series, No. 202, *Treatment of Water by Granular Activated Carbon,* M.J. McGuire and I.H. Suffet, eds., pp. 304-318, American Chemical Society, 1983.

11. "Alternatives to Gas Chromatography/Mass Spectrometry for the Analysis of Organics in Drinking Water," W.H. Glaze, *Org. Carcinog. Drinking Water,* N.M. Ram, E.J. Calabrese, R.F. Christman, eds., Publisher: Wiley, Newyour, New York (1986).

12. "Chemistry of Ozone, By-Products and their Health Effects," W.H. Glaze, *AWWA Semin. Ozonation,* Annu. Conf., l-15, Publisher: Am. Water Works Assoc., Denver, CO (1986).

13. "A Bench Scale Study of the UV/Ozone Process for TOC Removal from Groundwater," P. Kreft, M.L. Arora, J.M. Montgomery, E. Leitis and W.H. Glaze, Annu. Conf., *Amer. Water Works Assoc.* 1986, 165 (1986).

14. "The Mechanism of Photolytic Ozonation," G.R. Peyton, W.H. Glaze, in *Aquatic Photochemistry*," W. Cooper, R. Zika (eds.), ACS Symposium Series No. 327, pp. 76-88 (1987).

15. "Ozone-Hydrogen Peroxide Systems for Control of Organics in Municipal Water Supplies," W.H. Glaze, J.W. Kang, M. Aieta, *The Role of Ozone in Water and Wastewater Treatment: Proceedings of the Second International Conference* (Edmonton, Alberta, Canada), D.W. Smith and G.R. French, eds., pp. 233-244 (1987).

16. "Application of Closed Loop Stripping and XAD Resin Adsorption for the Determination of Ozone By-Products from Natural Water," W.H. Glaze, M. Koga, E.C. Ruth, D. Cancilla, in *Biohazards of Drinking Water Treatment,* Richard A. Larson, ed., Lewis Publishers, pp. 201-214 (1989).

17. "The Big Switch," S. Liang, G.F. Stolarik, C.H. Tate, W.H. Glaze, in *Ozone in Water Treatment,* Vol. I, Proceedings, Ninth Ozone World Congress, New York, NY, International Ozone Association, Zurich, Switzerland, pp. 61-80 (1989).

18. "Evaluation of the Ozone-Hydrogen Peroxide Process Using Tetrachloroethylene as a Model Compound," W.H. Glaze, J.W. Kang, in *Ozone in Water Treatment,* Vol. I, Proceedings, Ninth Ozone World Congress, New York, NY, International Ozone Association, Zurich, Switzerland, pp. 596-618 (1989).

19. "Oxidation of 1, 2-Dibromo-3-chloropropane (DBCP) using Advanced Oxidation Processes," W.H. Glaze, Y. Lay, in *Ozone in Water Treatment,* Vol. I, Proceedings, Ninth Ozone World Congress, New York, NY, International Ozone Association, Zurich, Switzerland, pp. 688-708 (1989).

20. "Chemical Models of Advanced Oxidation Processes," W.H. Glaze, J.W. Kang, Proceedings of the Symposium on Advanced Oxidation Processes, Toronto, Canada, June 4-5, 1990.

21. "Characterization of Natural Waters for Potential to Oxidize Organic Pollutants with Ozone," W.H. Glaze, S. Guittonneau, J.P. Duguet, O. Wable, Proceedings, 10th Ozone World Congress and Exhibition, Monaco, International Ozone Association, Zurich, Switzerland.

22. "Treatment of Hazardous Waste Chemicals Using Advanced Oxidation Processes," W.H. Glaze, J.W. Kang, S.S. Zigler, Proceedings, 10th Ozone World Congress and Exhibition, Monaco, International Ozone Association, Zurich, Switzerland.

23. "Ozone Disinfection By-Products: Optimization of the PFBHA Derivatization Method for the Analysis of Aldehydes," M.J. Sclimenti, S.W. Krasner, W.H. Glaze, H.S. Weinberg, *Water Qual. Technol.* Conf., Volume Date 1990, 477 (1991).

24. "Trends in Aldehyde Formation and Removal Through Plants Using Ozonation and Biological Active Filters," W.H. Glaze, H.S. Weinberg, S.W. Krasner, M.J. Sclimenti, Annu. Conf., Amer. *Water Works Assoc.,* (Water Qual. New Decade), 913 (1991).

25. "Modification and Application of Hydrogen Peroxide Analysis in Ozonation Plant Surveys," H.S. Weinberg, W.H. Glaze, J.J. Pullin, *Water Qual. Technol Conf.,* Volume Date 1991, 225, (1992).

26. "The Dilemma of Managing Disinfection By-Products," in *Protecting Drinking Water Quality at the Source,* University of California Water Resources Center, Riverside, Calif., Report No. 76, ISSN 0575-4968, October, 1991, pp. 87-94.

27. "Risks of Alternative Disinfectants," Proceedings of the International Conference on Environmental Epidemiology and International Conference on Exposure Assessment," National Institute of Public Health, Cuernavaca, Mexico, August 25-30, 1992.

28. "The TiO_2-Mediated Photocatalytic Degradation of Chloroalkenes in Water," Proceedings of the 1st International Conference on TiO_2 Photocatalytic Purification and Treatment of Water and Air, London, Ontario, Canada, November 8-13, 1992.

29. "Destruction of Vapor Phase Halogenated Methanes by Means of Ultraviolet Photolysis," G.A. Loraine, W.H. Glaze, *Proc. Ind. Waste Conf.,* Volume Date 1992, 47th, 309 (1993).

30. "Formation and Removal of Aldehydes in Plants that use Ozonation," H.S. Weinberg, W.H. Glaze, S.W. Krasner, M.J. Sclimenti, *J. Amer. Water Works Assoc.*, 85,72 (1993).

31. "Control of Polar By-Product Formation in Ozonation Plants," H.S. Weinberg and W.H. Glaze, *Water Qual. Technol. Conf.,* Volume Date 1992, 1407 (1993).

32. "Bromate Occurrence and Control: Pilot- and Full-Scale Studies," S.W. Krasner, W.H. Glaze, H.S. Weinberg, P.A. Daniel, Annu. Conf., *Amer. Water Works Assoc.*, (Water Research), 55 (1993).

33. "Assessment of Industrial Wastewater Treatment Technologies: A Progress Report," W.H. Glaze, S. Homewood, K. Iwamasa, C. Tolman, F. Tomei, W. Tumas, ACS Emerging Technologies in Hazardous Waste Management IV, Atlanta, GA, September 19-21, 1994.

REVIEW PAPERS

1. Organometallic Chemistry Reviews. Annual Surveys of Organometallic Chemistry. Lithium and Sodium (1967-72).

2. "Polymerizations Initiated by Alkyllithium Compounds," H.L. Hsieh and W.H. Glaze, Rubber Reviews, 43, 22-73 (1970).

3. "Oxidation of Organic Constituents in Drinking Waters," Chapter for Monograph in commemoration of 10th anniversary of U.S. Environmental Protection Agency (1980).

4. "Alternatives to GC/MS for the Analysis of Organics in Drinking Water" in *Organic Carcinogens in Drinking Water,* N . Ram, E. Calabrese and R. Christman, Eds., John Wiley Inc., NY (1986), pp. 153-172.

5. "Reaction Products of Ozone: A Review," *Environmental Health Perspectives,* **69,** 151-157 (1986) [October].

6. "Ozone in Drinking Water Treatment," *Environ. Sci. & Technol.,* **21,** 224-230 (1987).

7. "Oxidation in Water Treatment: A Survey of Current Knowledge and Research Needs," with L. Bauersachs and M. Gold, August, 1988.

8. "Chemical Oxidation," Chapter 12 in *Water Quality and Treatment,* F. W. Pontius, Ed., American Water Works Association, McGrawf-Hill, NY, 1990, pp. 747-780.

REPORTS AND SPECIAL MATERIALS

1. "A Feasibility Study on the Use of Solar Energy for Desalination of Water," (with Y.P. Gupta, D.J. Halsey, D.E. Henley, A.F. McCormack, E.C. Rees, L.C. Fitzpatrick and others), Report to Texas Department of Water Resources, Contract No. 14-70028, W.H. Glaze, Principal Investigator.

2. "A University Related Research Park for Denton, Texas: A Feasibility Study," Phase I Report to City of Denton and Greater Denton Industrial Development Board.

3. "Organics in Drinking Water: A New Concern, "(with C. Cowan, D. Brannum and others), 5 minute dual projector slide/tape show, prepared under contract to U.S.E.P.A. Region VI, W.H. Glaze, Principal Investigator and Technical Director.

4. "Control of Trihalomethanes in Drinking Water," 15 minute dual projector slide/tape show prepared under contract to U.S.E.P.A. Region VI, W.H. Glaze, Principal Investigator and Technical Director.

5. "Oxidation of Water Supply Refractory Species by Ozone with Ultraviolet Radiation," W.H. Glaze, G.R. Peyton, F.Y. Huang, J.L. Burleson, and P.C. Jones, U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, Report No. EPA-600/2-80-110, 1980.

6. "Evaluation of Biological Activated Carbon for Removal of Trihalomethane Precursors," W.H. Glaze, J.L. Wallace, K.L. Dickson, D.P. Wilcox, K.R. Johansson, E. Chang, A.W. Busch, B.G. Scalf, R.K. Noack and D.P. Smith, Jr., U.S. Environmental Protection Agency, Municipal Environmental Research

Laboratory, Cincinnati, Ohio, Report of Cooperative Agreement CR-806157, 1981.

7. "Pilot Scale Evaluation of Biological Activated Carbon for the Removal of THM Precursors," W.H. Glaze, U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA., Report No. EPA-600/2-82-046, 1982.

8. "Water Chemicals Codex," National Academy Press, Report of Committee on Water Treatment Chemicals, W.H. Glaze, Chair 1982.

9. "Analysis of Chlorinated Organics Compounds Formed During Chlorination of Wastewater Products," W.H. Glaze, J.L. Burleson, J.E. Henderson, P.C. Jones, W. Kinstley, G.R. Peyton, R. Rawley, F.Y. Saleh and G. Smith, U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA., Report
No. EPA-600/S4-82-072, 1983.

10. "Optimization of Microextraction Methods for Analysis of Organics in Water," W.H. Glaze, C.C. Lin, J.L. Burleson, J.E. Henderson, D. Mapel, R. Rawley and D.R. Scott, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, Report No. EPA-600-34-83-052, January 1984.

11. "Pilot Scale Evaluation of the Ozone/UV Process for Removal of THM Precursors," W.H. Glaze, C.R. Peyton, B. Sohm, and D. Meldrum, U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, Report No. EPA-600/52-84-136, September 1984.

12. "Ground Water Quality in California: A Review of Scientific and Technical Issues, CA State Water Resources Control Board, Contract Report #5-125-250-0, July 1986 (with D. Mackay, *et al.*).

13. "Drinking Water Quality Issues in California," with D. Mackay, resource document for University of California Water Quality Task Force, July, 1987.

14. "Identification and Occurrence of Ozonation By-Products in Drinking Water," with H. Weinberg, J. Cavanagh and N. Scheller, Final Report to AWWA Research Foundation, 1992.

RECENT NATIONAL AND INTERNATIONAL PRESENTATIONS

1. "Ozone By-Products in Drinking Water Produced Under Full-Scale Treatment Conditions," with M. Koga, D. Cancilla, K. Wang, C. Tate, M. Aieta, M. McGuire,

and M. Davis, 195th National Meeting of the American Chemical Society in Los Angeles, September 25-30, 1988.

2. "Chemical Processes: Land," Association of Environmental Engineering Professors, Conference on Fundamental Research Directions in Environmental Engineering, Washington, DC, November 8, 1988.

3. "Reaction Kinetics and By-Products of Advanced Oxidation Processes in Water Treatment," 9th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Washington, DC, November 13, 1988.

4. "Analytical Techniques for Measuring Ozone By-Products," Water Quality Technology Conference of AWWA, St. Louis, MO, November 16, 1988.

5. "Oxidants in Water Treatment," Technology Transfer Conference of AWWA and Canadian Water and Waste Water Association, Edmonton, Alberta, Canada, April 6, 1989.

6. "Peroxide/Ozone for Control of Disinfection By-Products, Taste and Odor, and Pathogens," with M. McGuire, M. Buehler, M. Aieta, and C. Tate, IOA Symposium: Wasser Berlin '89, Berlin, West Germany, April 10-12, 1989.

7. "Separation and Identification of Ozonation Disinfection By-Products in Drinking Water," 19th International Symposium on Environmental Analytical Chemistry, Jekyll Island, GA, May 22-24, 1989.

8. "Evaluation of the Ozone-Hydrogen Peroxide Process in a Semi-Batch Reactor Using Tetrachloroethylene as a Model Compound," with J. Kang, 9th Ozone World Conference of IOA, New York City, June 3-9, 1989.

9. "Oxidation of 1, 2-dibromo-3-chloropropane (DBCP) Using Advanced Oxidation Processes," with Y. Lay, 9th Ozone World Conference of IOA, New York City, June 3-9, 1989.

10. "Advanced Oxidation Processes for Treating Groundwater Contaminated with TCE and PCE: Effects of Lime Softening," with N. Patania, D. Ferguson, M. Aieta, and R. Giles, AWWA Annual Conference, Los Angeles, June 18-22, 1989.

11. "Applications of Advanced Oxidation Processes for Treatment of Groundwater Containing Dibromochloropropane (DBCP)," with Yii-Shyan Lay and Joon-Wun Kang, AWWA Water Technology Conference, Philadelphia, Pa, November 12-16, 1989.

12. "Chemical Models of Advanced Oxidation Processes," with J. W. Kang, Symposium on Advanced Oxidation Processes, Toronto, Canada, June 4-5, 1990.

13. "Ozone Disinfection By-Products. Optimization of the PFBHA Derivatization Method for the Analysis of Aldehydes," American Water Works Association, Water Quality Technology Conference, San Diego, Calif., Nov. 11-15, 1990.

14. "Trends in Aldehyde Formation and Removal Through Plants Using Ozonation and Biological Active Filters," W.H. Glaze, H.S. Weinberg, S.W. Krasner, and M.J. Sclimenti, Proceedings, Amer. Water Works Assoc. Annual Conference, Philadelphia, PA, June 27, 1991.

15. "The Dilemma of Competing Risks in Drinking Water," W.H. Glaze, *Conference on Drinking Water and Health in the Year 2000,* American Water Works Association Research Foundation, Washington, DC, Sept. 2, 1991.

16. "Research Strategy for the Year 2000," W.H. Glaze, Conference on Drinking Water and Health in the Year 2000 American Water Works Association Research Foundation, Washington, DC, Sept. 2, 1991.

17. "The Dilemma of Competing Risks in Drinking Water," Donald R. Boyd Award Address, Association of Metropolitan Water Agencies, West Palm Beach, FL, October 14-15, 1991.

18. "Formation and Removal in Filters of Aldehydes by the Ozonation of Drinking Water," W.H. Glaze and H. Weinberg, 3rd Conference on Drinking Water, Montreal, Canada, November 14, 1991.

19. "Research Issues in Disinfection By-Products," Presented to International Life Sciences Institute, Board of Members and Board of Trustees Meeting, Miami Beach, FL, January 14, 1992 (invited).

20. "Chlorinated By-Products from the TiO_2-Mediated Photocatalysis and H_20_2-Photooxidation of Chloroalkenes in Water," (with J. Kenneke and J. Ferry), ACS Natl. Meeting, San Francisco, CA, April, 1992.

21. "Health Risks of Disinfection By-Products," ISEE/ISEA International Meeting, Cuemavaca, Mexico, August 26, 1992 (invited).

22. "Environmental Professionals for the Next Century: Trouble at the Academy," National Symposium on New Directions in Clean Water Policy, UCOWR Natl. Meeting, Charlottesville, VA, July 28-30, 1992 (invited).

23. "Advanced Oxidation Processes: Overview and Prospects," National Seminar on Environmental Protection, Tampere, Finland, May 20-22, 1992 (invited).

24. "Ozonation By-Products," IWEM Scientific Section, Seminar on Treatment By-Products, Birmingham, England, November 25, 1992 (invited).

25. "An Overview of Advanced Oxidation Processes for Water and Wastewater Treatment," W.H. Glaze, 1st International Conference on Advanced Oxidation Technologies for Water and Air Remediation, Ontario, Canada, June 25-30, 1994.

26. "By-Products of Ozonation and Advanced Oxidation," 1st International Conference on Water Treatment By-Products, Poiters, France, September 28-30, 1994.

27. "Advanced Chemical Technologies for Air and Water Treatment," Florida Environmental Chemistry Conference, Orlando, FL, October 26-27, 1994.

28. "Evolution of Environmental Analysis,"7th Annual California Pesticide Residue Workshop, Sacramento, CA, March 12-17, 1995 (invited).

29. "Environmental Science & Technology at the Turn of the Century: Opportunities and Challenges for the Academic Community," A.I. Virtanen Centennial Symposium, The Frontiers of Contemporary Science, Kuopio, Finland, June 5-7, 1995 (invited).

30. "By-Products of Oxidation Proceses in Water and Wastewater Treatment," ACS 2 10st National Meeting, Environmental Chemistry Division, Chicago, IL, August 20-24, 1995.

CURRICULUM VITAE

GORDON W. NEWELL, Ph.D., Fellow-A.T.S.

ACADEMIC BACKGROUND

University of Wisconsin, Madison, Wisconsin

B.A., Chemistry

M.S., Biochemistry

Ph.D., Biochemistry

PROFESSIONAL EXPERIENCE

1988-

Consultant: General and Environmental Toxicology

1982 - 1988

Electric Power Research Institute: Senior Program Manager,
Health Studies Program, Risk and Health Sciences Department.

The principal duties and responsibilities of this position included:

- Planning and directing a broadly-based program of health-related projects associated with the generation, transmission and distribution of electrical energy
- Identification of research problems and development of projects to investigate them; i.e., mechanisms of action of criteria air pollutants, clinical investigations of toxicants to asthmatics, investigation of electric and magnetic fields as teratogens or carcinogens, occupational risk assessment of PCBs, biological significance of coal-produced fly ash
- Improvement in extrapolation of animal data to humans through studies of toxicokinetic methodology and structure activity correlations
- Responsible for the recruitment and management of a 5 member staff, four of which were professionals
- Management of a $5 million budget.

1978 - 1982

National Academy of Sciences/National Research Council:

Associate Executive Director, Board on Toxicology and Environmental Health Hazards; Project Director, Committee on Toxicology.

- The principal duties and responsibilities of this position included:
- Participation in the management of a group of multidisciplinary scientists composing the Board staff
- Assisting in recruitment and management of a 32-person staff, of which some 18 were professionals
- Aiding in management of a $2.0 million per year budget
- Development of studies on contemporary problems in toxicology and environmental health, e.g., contaminants in drinking water, epidemiology studies of environmental pollutants, composite fibers, termiticides as housing contaminants
- The conduct of studies assessing risks and benefits of specific substances, e.g., inhalation exposure limits and risk assessment of chlorpyrifos, assessment of formaldehyde health effects, health risks of ordnance disposal waste in drinking water, long-term health risks from short-term exposure to carcinogens
- Toxicological emergency response reports following accidental spills of chemicals, e.g., 1,2,-dichloroethane, O-nitroaniline, formaldehyde
- Development of criteria for short-term exposures to air pollutants, e.g., short-term public limits (STPLs), short-term public emergency limits (SPELs), emergency exposure limits (EELS)
- Development of principles of toxicological interactions associated with multiple chemical exposures

1950-1978

SRI–International

1968-78, Director, Department of Toxicology

1965-68, Director, Division of Industrial Biology

1960-65, Assistant General Manager, Life Sciences Div.

1958-60, Manager, Industrial Biology

1950-58, Senior Biochemist

The principal duties and responsibilities of these positions included development of a program in toxicology which initially included only a few scientists of limited disciplines; over time it evolved into a 50-member technical and professional staff of multidisciplinary capabilities. Financial support was a blend of government and commercial contracts interspersed with NIH grants.

The diversity of investigations conducted is shown by the following examples: long-term investigations of fluoride effects in dairy cattle; nutritional value of tallow and yellow grease in poultry and cattle rations; acute and chronic studies of new food products, food additives, pesticides, and drugs; inhalation studies of industrial and agricultural chemicals; investigation of lipid oxidation in the cat; nutritional and toxicological experiments with Japanese quail; biochemistry of acetylcholine and cholinesterase inhibitors; development of respiratory irritants; acute and chronic toxicological effects of environmental contaminants in fish and invertebrates: *in vivo* and *in vitro* mutagenesis studies of food additives, drugs, industrial chemicals, and mixtures.

Among some of the more unique contributions and developments which occurred under my direction are the following:

- Identification of oxidized lipids in red meat tuna as the cause of yellow fat disease (steatosis) in cats
- Development of the Japanese quail as a laboratory model for evaluating the effects of pesticides on upland game
- One of the first laboratories to develop an aquatic toxicology facility with extensive capabilities for studying fish, invertebrates, and algae
- Early recognition of mutagenesis as an evolving discipline; the department was one of the first in the country with broad-based capabilities to be able to conduct both *in vitro* and *in vivo* mutagenesis studies
- Development of a natural product obtained from the soapberry plant; effective against schistosomiasis, and also shown to be a sensitive emetic agent
- Development of a sensitive technique for evaluating the potential of pet collars to cause skin irritation, and for their efficacy to control fleas on cats
- Developed and coordinated multidisciplinary teams of scientists which worked together investigating broad research problems. Capabilities included analytical chemistry, biochemistry, mutagenesis (*in vivo* and *in vitro*), pharmacology, mammalian toxicology, inhalation toxicology, aquatic toxicology, and pathology.

1949-1950

Wallace and Tiernan Company: Biochemist and coordinator of clinical studies.

Responsible for establishing and coordinating clinical trials of new drugs; conducted biochemical and toxicological research on candidate pharmaceuticals.

DEMONSTRATION OF SCIENTIFIC JUDGEMENT

Scientific Advisory Boards

Heritable Translocation Workshop, Review of Parameters for an Acceptable Protocol, sponsored by the National Institute of Environmental Health Sciences, May 26-27, 1977, Menlo Park, California, organizer and chairman.

ad hoc NAS/NRC Review Panel on Experimental Design of Toxicological Protocols for study of Irradiated Foods, for US Army; member, 1977-78.

Toxicology Committee–Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee, member, 1979-82.

Water Quality Standards Committee–Environmental Protection Agency, member, 1979-80.

Heritable Translocation Committee, Genetic Toxicology Program, Office of Pesticides and Toxic Substances–Environmental Protection Agency, member, 1979-81.

Micronucleus Assay Committee, Genetic Toxicology Program, Office of Pesticides and Toxic Substances–Environmental Protection Agency, member, 1979-81.

Congressional Oversight Hearing on Barium in Drinking Water. Expert witness presentation on the use of safety factors in assessinghuman risks from exposure to toxic chemicals, November 5, 1979, Chicago, lllinois.

Dominant-Lethal Assay Workgroup–International Commission for Protection Against Environmental Mutagens and Carcinogens, member, 1981-82.

Scientific Advisory Council–Society for Risk Analysis, member, 1981-82.

Science Advisory Board–National Center for Toxicological Research, member, 1982-85.

External Review Committee for the Environmental and Occupational Health Sciences Institute, Rutgers Medical School, Piscataway, New Jersey, May 28-29, 1986.

Study Sections

Animal Resources Advisory Committee–National Institutes of Health, member, 1965-68

Oversight Review Committee for the National Library of Medicine Program to Develop a Laboratory Animal Data Bank–National Research Council/National Academy of Sciences, member, 1976-78.

Ad hoc Animal Facilities Grant Review Committee–National Institutes of Health, member, March 1987 and 1989 and chairman, March 1988.

Scientific Review Committees

Council on Accreditation–American Association for Accreditation of Laboratory Animal Care, member, 1967-78.

White House Conference on Food, Nutrition and Health, Washington, DC; December 3-4,1969; invited participant.

Planning and Organizing Committee–Toxicology Laboratory Accreditation Board, member, 1976-77.

Conference on Comparative Chemical Mutagenesis, sponsored by the National Institute of Environmental Health Sciences, November l-4, 1977, Research Triangle Park, North Carolina, invited panelist.

Board of Directors–Toxicology Laboratory Accreditation Board, member, 1978-82.

Office of Criteria Assessment, EPA; Member, ad hoc committees to review and critique criteria documents on air and water, 1978-83.

Reviewer of EPA's annual report to Congress, "Research Outlook; 1980-83.

Professional Standards Evaluation Board–Academy of Toxicological Sciences, member, 1981-85, 1987-89; Chairman, 1983-85.

Administrative Panel on Laboratory Animal Care, Stanford University; member, 1983-90.

NSF - Member, Review and Evaluation Committee of major risk analysis document commissioned by OSTP for OMB, 1984-85.

Chancellor's Advisory Committee to the Director of Laboratory, Animal Care, University of California, Berkeley; Chairman, 1984-94.

Northeast Regional Environmental Public Health Center; Scientific Advisory Committee, member, 1987.

Council for Health and Environmental Safety of Soils, Governing Board, member, 1987-90.

American Council on Science and Health, Board of Scientific Advisors, member, 1989
EPA - Consultant to Clean Air Scientific Advisory Committee, 1991-93.

Site Visit Committees

I have kept no formal record of government-related site visits. Over the years, however, I participated in numerous individual and center application reviews for NIH. Also, many site visits were conducted for the American Association for the Accreditation of Laboratory Animal Care (AAALAC); although these were not directly involved with toxicology, the Association's assurance that an inspected and reviewed animal research facility meets established standards is vital to the conduct of toxicological-related investigations.

AAALAC Site Visits (Committee chairman, secretary, or member)

Washington State University
University of Oregon
Oregon Regional Primate Center
Los Alamos National Laboratory
Southwest Medical Research Foundation
University of Southern California
University of California, Irvine
University of California–San Diego
Fitzsimmon Army General Hospital
University of Utah
Utah State University
Oregon State University
Palo Alto Veterans Hospital
Menlo Park Veterans Hospital

University of California at Los Angeles

University of Hawaii

Stanford University

University of Texas–San Antonio

Portland Veterans Hospital

University of Montana

Palo Alto Medical Research Foundation

University of Idaho

INVITED PAPERS, CONFERENCES, AND SEMINARS

United States–Japan Mutagenesis Workshop, sponsored by the National Institute of Environmental Health Sciences, December 9- l 1, 1974, Honolulu, Hawaii, *invited participant.*

"Impact of Short-Term Tests for Toxicological Evaluation by Industry," presented by *invitation* for the International Symposium on New Developments in Mutagenicity Testing of Environmental Chemicals, Zinkovy Castle, Czechoslovakia, October 13-l 7, 1975.

Symposium on Present Status and Goals of Collaborative Studies in Toxicology at Annual Meeting of AOAC, October 17-l 8, 1977, Washington, D.C. *Moderator* for the Panel on *In Vivo* Assays.

Workshop on Health and Environmental Effects of Coal Gasification and Liquifaction, sponsored by DOE, EPA, and HEW, August 20-25, 1978, Xerox Training Center, Leesburg, Virginia, *invited panelist.*

Advisory Workshop on Carcinogenic Effects of Coal Conversion, sponsored by the Electric Power Research Institute, September 26- 28, 1978, Pacific Grove, California, *invited participant.*

"Short-Term Bioassays as Indicators for Potential Mutagens and Carcinogens–Current Status," presented by *invitation* to the AMA Congress on Occupational Health, September 14-I 6, 1978, Tuscan, Arizona.

Workshop on Systems to Detect Induction of Aneuploidy by Environmental Mutagens, sponsored by the National Institute of Environmental Health Sciences, November 5-8, 1978, Savannah, Georgia, *invited participant.*

"Organics in Drinking Water," *keynote address* presented to the 55th Annual Meeting of the North Carolina American Waterworks Association, November 12-l 5, 1978, Winston-Salem, North Carolina.

"The Relationship of Genetic Toxicology to Other Areas of Toxicology," presented by *invitation* to the Environmental Mutagen Society Training Course, February 5-8, 1979, Cincinnati, Ohio.

"Pros and Cons: An Update on Saccharin," presented by *invitation* to the Annual Meeting of Research and Development Associates for Military Food and Packaging Systems, April 24-25, 1979, New York City.

"Toxicological Considerations in Assessing Health Effects of Our Water Supplies," presented by *invitation* to the Water Supply Engineering Short Course, School of Public Health, University of North Carolina, May 21-23, 1979, Chapel Hill, North Carolina.

Symposium on Health Assessment of Environmental Pollutants at the Air Pollution Control Association Annual Meeting, June 29, 1979, Cincinnati, Ohio, *panel participant.*

World Conference, "Science in the Service of Life," sponsored by lnstitut de la Vie. *panel participant* on "Protection of Human Chromosomes Against Environmental Mutagens and Carcinogens," July 8-14, 1979, Vienna, Austria.

"The Quality, Treatment and Monitoring of Water for Laboratory Rodents," presented by *invitation* to the Fourth Charles River International Symposium on Laboratory Animals, October 29-31, 1979, Boston, Massachusetts.

International Conference on "Biology and the Future of Mankind," 20th Anniversary Meeting of the Institut de la Vie. Presented by *invitation* "Indoor Environmental Pollutants" as a part of the Symposium on the Influence of External Factors on Biological Functions, October 8-11, 1980, Lausanne, Switzerland.

"Overview of Formaldehyde: Chemistry, Occurrence, Biochemistry, Environmental-Occupational Exposure, Environmental Fate, Human Effects," presented by *invitation* to the Third CIIT Conference on Toxicology, November 20-21, 1980, Raleigh, North Carolina.

"Risk/Benefit Analysis," presented by *invitation* to the Predictive Toxicology Environmental Toxicology Seminar, University of California, Davis, February 26, 1981, Davis, California.

Sigma Xi Chesapeake Chapter, *lecturer*, "The Academy, Nature—Purposes—Organization—Operation—Growth." May 7, 1981, Edgewood, Maryland.

"The Relation of the National Academy of Sciences Board on Toxicology and Environmental Health Hazards to Various Government Agencies," presented by *invitation* to the Spring Symposium of the mid-Atlantic Chapter of the Society of Toxicology, June 13, 1981, Rutgers University Medical School, Piscataway, New Jersey.

"Inconsistencies Between *In Vitro* and *In Vivo* Mutagenesis Results and the Toxicological Evaluation of Pestacides, "presented by *invitation* to the Third International Conference on Environmental Mutagens, September 19-27, 1981, Kyoto, Japan.

"Scientific Programs of the National Research Council," presented by *invitation* as a seminar at the University of the Philippines at Los Banos, October 6, 1981, Laguna, the Philippines.

National Symposium on "Genetic Toxicology—An Agricultural Perspective," sponsored by the Departments of Agriculture, Energy, and the EPA, November 1-5, 1981, University of California, Davis, *symposium planning committee and discussion leader.*

"Ongoing Activities of the Committee on Toxicology: Development and Use of Special Standards," presented by *invitation* to the Workshop on the Development and Application of Occupational and Environmental Health Standards at the 1981 JANNAF Safety and Environmental Protection Meeting, November 17-20, 1981, Kennedy Space Center, Florida.

"The Acute Toxicity of Five Organophosphate Pesticides: A Comparative Study (Administered by the Dermal, Oral, Intravenous, and Inhalation Routes)," presented by *invitation* at the 1982 Annual Summer Meeting of the Toxicology Forum , July 21, 1982, Aspen, Colorado.

"The Role of Risk Assessment in United States Regulatory Decisions," presented by *invitation* at the International Workshop on Environmental Mutagenesis Carcinogenesis and Teratogenesis, May 25-June 1, 1983, Shanghai, China.

Symposium on "The Future of Animals in Research and Teaching," annual meeting of the Society of Toxicology, March 7-l 0, 1983, Las Vegas, Nevada; *symposium organizer and moderator.*

Symposium on "Current Practices for Increased Efficiency in the use of Animals for Research and Testing," annual meeting of the Society of Toxicology, March 12-15, 1984, Atlanta, Georgia; *symposium organizer and moderator*.

Symposium on "Toxicokinetics—A Tool for the Toxicologist," annual meeting of the American College of Toxicology, November 27-29, 1984, Arlington, Virginia; *symposium organizer and moderator*.

Organizing committee chairman, Northern California Regional Chapter of the Society of Toxicology, Spring, 1986.

7th Annual Meeting of The American College of Toxicology, *Program Chairman of meeting and Workshop Chair* of "Pharmocokinetics: Discussion and Demonstration." November 17-19, 1986, Philadelphia, Pa.

80th Annual Meeting of The Air Pollution Control Association, *program coordinator of Life Sciences Symposia*, June 1987, New York, NY.

University of California a Toxic Substances Seminar Series, "New Approaches for Improved Risk Assessment and Risk Communication," October 18, 1989, Berkeley, CA; *invited speaker.*

Annual Meeting of the California Board of Agricultural Commissioners; "The Use of Toxicology in Risk Assessment and Risk Communication," December 7, 1989, Sacramento, CA., *invited speaker*.

Forum on "Health Effects of Electromagnetic Fields," Carcinogenesis Speciality Section, annual meeting of Society of Toxicology, February 25, 1992, Seattle, WA., *invited speaker and discussant*.

Third International Conference on Electrical and Electronic Materials, Session on Health and Safety Aspects, June 9, 1992, Millbrae, CA; *invited speaker and session chair.*

PARTICIPATION IN PROFESSIONAL SOCIETIES

Society of Toxicology
- Liaison Representative with EMS, 1974-80
- Regulatory Affairs and Legislative Assistance Committee, member, 1980-81
- Mechanism Section, organizing committee and member, 1981-82
- Animals in Research Committee, member, 1982; Chairman, 1982-83.
- Northern California Regional Chapter, President, 1986;
- Nominating Committee Chairman, 1989.

American College of Toxicology
- President-Elect, 1986
- President, 1987
- Councilor, 1986-88

Environmental Mutagen Society
- Councilor, 1977-79
- Vice-President, 1981
- President, 1982

Society for Risk Analysis
Organizing Committee, member, 1980-81
Treasurer, 1981
Scientific Advisory Council, member, 1981-82

American Academy of Industrial Hygiene

American Association for the Advancement of Science

American Board of Industrial Hygiene

American Chemical Society

American Industrial Hygiene Association

American Institute of Nutrition

Animal Nutrition Research Council

International Society for the Study of Xenobiotics

International Society of Regulatory Toxicology and Pharmacology

New York Academy of Sciences

Research Society of America

Sigma Xi

Society of Ecotoxicology and Environmental Safety

Society of Environmental Toxicology and Chemistry

Western Pharmacology Society

OTHER AFFILIATIONS

The Wine Institute Technical Advisory Committee, member, 1952-74

Palo Alto Unified School District
Numerous citizen committees for improvement and guidance, 1958-69

Palo Alto-Stanford Hospital Center
Board of Directors, secretary, 1963-68

Palo Alto Chamber of Commerce
Board of Directors, member, 1966-69

Community Blood Reserve
Board of Directors, member, 1966-74

National Swimming Pool Foundation
Board of Directors, member, 1979-82, 1985-88

American Lung Association of Santa Clara-San Benito Counties
Board of Directors, member, 1986-87

BIOGRAPHICAL LISTINGS

American Men and Women of Science

Dictionary of International Biography

Marquis Who's Who in the East

Marquis Who's Who in the West

National Register of Scientific and Technical Personnel

Who's Who in the United States

World Who's Who in Science

HONORS, PRIZES, AWARDS

Academy of Toxicological Sciences, Fellow

American Academy of Industrial Hygiene, Diplomate—Toxicology

Wilson and Company Fellowship, University of Wisconsin

Novadel Agene Fellowship, University of Wisconsin

White House Conference on Food, Nutrition and Health

Phi Delta Kappa (International Education Fraternity)—"Man of the Year"

EDITORIAL BOARDS OF SCIENTIFIC JOURNALS

Laboratory Animal Science, 1969-73

Mutation Research, 1975-79

Risk Analysis, 1981-

Regulatory Toxicology and Pharmacology, 1982-93

Inhalation Toxicology, 1987-94

PUBLICATIONS

Author of 80 technical publications and papers, plus several hundred toxicology reports (client confidential).

Original Research in Peer Reviewed Journals

1. Elvehjem, CA., J.E. Gonce, and G.W. Newell. **The effect of Vitamin E on reproduction in dogs on milk diets.** J. Pediatrics *24*:436, 1944.

2. Newell, G.W. and C.A. Elvehjem. **Studies on the growth of rats raised on chocolate milk.** Science *99*:411, 1944.

3. Newell, G.W., W.H. Peterson, and C.A. Elvehjem. **The value of dried penicillin mycelium as a supplement in practical chick rations.** Poultry Sci. *26*:284, 1947.

4. Newell, G.W. and C.A. Elvehjem. **Nutritive value of keratin. III. Effect of source, particle size, and method of grinding**. J. Nutrition *33*:678, 1947.

5. Newell, G.W., T.C. Erickson, W.E. Gilson, S.N. Gershoff, and C.A. Elvehjem**. Role of "agenized" flour in the production of running fits.** J. Am. Med. Assoc. *135*:760, 1947.

6. Newell, G.W., S.N. Gershoff, F.H. Fung, and C.A. Elvehjem. **Effect of administering agenized amino acids and wheat gluten to dogs.** Am. J. Physiol. *152*:637, 1948.

7. Newell, G.W., T.C. Erickson, W.E. Gibson, S.N. Gershoff, and CA. Elvehjem. **Studies on human subjects receiving highly agenized food materials.** J. Lab. Clin. Med. *34*:239, 1949.

8. Newell, G.W., S.N. Gershoff, H.M. Suckle, W.E. Gilson, T.C. Erickson, and C.A. Elvehjem. **Feeding tests with chlorine dioxide-treated flour.** Cereal Chem. *26*:160, 1949.

9. Gershoff, S.N., G.W. Newell, and W.E. Stone. **Chemical studies of the brain in dogs with running fits.** Arch. Biochem. *21*:74, 1949.

10. Newell, G.W., A.K. Petretti, and L. Reiner. **Studies of the acute and chronic toxicity of undecylenic acid.** J. Invest. Dermatol. *13*:145, 1949.

11. Ney, L.F. and G.W. Newell. **The effect of sodium alkyl aryl sulfonate detergent on the growth of chicks.** Poultry Sci. *33*:297, 1954.

12. Schmidt, H.J., G.W. Newell, and W.E. Rand. **The controlled feeding of fluorine, as sodium fluoride, to dairy cattle.** Am. J. Vet. Res. *15*:232, 1954.

13. Newell, G.W. and H.J. Schmidt. **The effects of feeding fluorine, as sodium fluoride, to dairy cattle—a six year study.** Am. J. Vet. Res. *19*:363, 1958.

14. Calloway, D.H., G.W. Newell, W.K. Calhoun, and A.H. Munson. **Further studies of the influence of diet on radiosensitivity of guinea pigs, with special reference to broccoli and alfalfa.** J. Nutrition *79*:340, 1963.

15. Wohlers, H.C. and G.W. Newell. **A Field investigation of fluorosis in cattle.** J. Air Pollution Control Assoc. *14*:139, 1964.

16. Newell, G.W., T.E. Shellenberger, and D.R. Reinke. **Chronic effects of alcohol, muscatel, and sherry on the growth and performance of rats.** Toxicol. Appl. Pharmacol. *6:*696, 1964.

17. Shellenberger, T.E., G.W. Newell, R.M. Bridgman, and J. Barbaccia. **A subacute toxicity study of N-(-2=mercaptoethyl) benzene-sulfonamide S-(O,O-diisopropyl phosphorodithioate) and phthalimidomethyl-O, O-dimethyl phosphorodithioate with Japanese Quail**. Toxicology and Applied Pharmacology *7*:550, 1965.

18. Shellenberger, T.E. and G.W. Newell. **Toxicological evaluations of agricultural chemicals with Japanese quail.** (Cotumix cotumix japonica) J. Lab. Animal Care *15*:119, 1965.

19. Shellenberger, T.E., G.W. Newell, S.S. Okamoto, and A. Sarros. **In vivo response of rabbit whole blood cholinesterase following continuous intravenous infusion and percutaneous application of dimethyl organophosphate inhibitors**. Biochem. Pharmacol. *14*.943, 1965.

20. Shellenberger, T.E., R.M. Bridgman, and G.W. Newell. **In vivo inhibition of rabbit whole blood cholinesterase following intravenous infusion of a diethyl organophosphate inhibitor and reactivation with 2-PAM**. Life Sci. *4*:1973, 1965.

21. Shellenberger, T.E., R.F. Adams, H. Virgin, and G.W. Newell. **Erythrocyte and leukocyte evaluations of Coturnix quail**. Poultry Sci. *44*:1334, 1965.

22. Skinner, W.A., H.C. Tong, T.E. Shellenberger, and G.W. Newell. **Effect of organic compounds on reproductive processes. I. Alkylating agents from octamethylenediamine and various xylylene diamines**. J. Med. Chem. *8:*647, 1965.

23. Shellenberger, T.E., G.W. Newell, R.F. Adams, and J. Barbaccia. **Cholinesterase inhibition and toxicological evaluations of two organophosphate pesticides in Japanese quail.** Toxicol. Appl. Pharmacol. *8*:22, 1966.

24. Lemma, A., G. Brody, G.W. Newell, and R.M. Parkhurst. **Studies on the molluscicidal properties of Endod (Phytolacca dodecandra): 1. Increased potency with butanol extraction.** J. Parasit. *58*:104, 1972.

25. Maxwell, W.A. and G.W. Newell. **Considerations for evaluating chemical mutagenicity to germinal cells.** Environ. Health Perspectives *6:*47, 1973.

26. Anbar, M., G.W. Newell, and G.A. St. John**. Fate and toxicity of orally administered polyethylene phosphonates**. Fd. Cosmet. Toxicol. *11*:1001, 1973.

27. Jones, D.C.L., W.E. Davis, Jr., G.W. Newell, and D.P. Sasmore. **Modification of hexachlorphene toxicity by dieldrin and Aroclor 1254**. Toxicology *2*:309, 1974.

28. Jorgenson, T.A., W.A. Maxwell, M. Bamett, G.W. Newell, H.C. Tong, F. Tokuyama, S. Sutou, and W.A. Skinner. **Mutagenic studies of aziridine derivatives derived from various diamines**. Mutation Res. *31*:115-122, 1975.

29. Jorgenson, T.A., C.J. Rushbrook, G.W. Newell and R.G. Tardiff. **Study of the mutagenic potential of bis(2-chloroethyl) and bis(2-chloroisopropyl) ethers in mice by the heritable translocation test**. Toxicol. Appl. Pharmacol. *41*(1):196-197, 1977.

30. Dilley, J.V., N. Chemoff, D. Kay, N. Winslow, and G.W. Newell. **Inhalation toxicology studies of five chemicals in rats.** Toxicol. Appl. Pharmacol. *41*(1):196, 1977.

31. Poole, D.C., V.F. Simmon, and G.W. Newell. **In vitro mutagenic activity of fourteen pesticides**. Toxicol. Appl. Pharmacol. *41*(1):196, 1977.

32. Dilley, J.V., G.W. Newell, S. Schobert, D. Palmer, J. Dacre, and R. Shiotsuka. **The subacute oral toxicity of trinitrotoluene in rats, mice, and dogs.** Toxicol. Appl. Pharmacol *41*(1):220, 1977.

33. Dilley, J.V., C.A. Tyson, D.P. Sasmore, R.J. Spanggord, G.W. Newell, and J.C. Dacre. **Subacute oral toxicity of TNT and a TNT/RDX mixture to dogs and rodents**. Toxicol. Appl. Pharmacol. *45*:256, 1978.

34. Tyson, C.A., J.V. Dilley, D.P. Sasmore, R.J. Spanggord, G.W. Newell, and J.C. Dacre. **Single-dose and repeated-exposure toxicity of a complex wastewater from munitions manufacturing plants**. J. Toxicol. Environ. Health *9*(4):545-564, 1982.

35. Dilley, J.V., C.A. Tyson, R.J. Spanggord, D.P. Sasmore, G.W. Newell, and J.C. Dacre. **Short-term oral toxicity of a 2,4,6- trinitrotoluene in mice, rats and dogs**. J. Toxicol. Environ. Health *9*(4):565-585, 1982.

36. Dilley, J.V., C.A. Tyson, R.J. Spanggord, D.P. Sasmore, G.W. Newell, and J.C. Dacre. **Short-term oral toxicity of a 2,4,6- trinitrotoluene and hexahydro-1,3,5-trinitro-1,3,5- triazine (1:0,62) mixture in mice, rats, and dogs.** J. Toxicol. Environ. Health *9*(4):587-610, 1982.

37. Mustafa, M.G., C.H. Hassett, G.W. Newell and G.N. Schrauzer. **Pulmonary carcinogenic effects of ozone**. Annals of the New York Academy of Sciences 534:714-723 (1988)

Non-peer Reviewed Original Research

1. Erickson, T.C., W.E. Gilson, C.A. Elvehjem, and G.W. Newell. **Wheat gluten as a convulsant.** Proc. Assoc. Res. in Nervous and Mental Diseases *26*:164, 1946.

2. Newell, G.W., T.C. Erickson, W.E. Gilson, and C.A. Elvehjem. **Effect of wheat gluten on the electroence-phalograms of dogs**. Proc. Soc. Exptl. Biol. Med. *65*:115, 1947.

3. Newell, G.W., S.N. Gershoff, T.C. Erickson, W.E. Gilson, and C.A. Elvehjem. **Effect of feeding moderate levels of commercially agenized flour to dogs.** Proc. Soc. Exptl. Biol. Med. *69*:1, 1948.

4. Newell, G.W., T.C. Erickson, W.E. Gilson, S.N. Gershoff, and C.A. Elvehjem. **The effect of feeding agene-treated food materials to experimental animals and human beings.** Trans. Am. Assoc. Cereal Chemists *7*:1, 1949.

5. Newell, G.W. and W.W. Carman. **Effect of methionine on the toxicity of crystalline "agene factor" against Leu-conostoc mesenteroides**. Fed. Proc. *9*:209, 1950.

6. Shellenberger, T.E. and G.W. Newell. **Japanese quail (Coturnix coturnix japonica), a useful laboratory animal for biological studies**. J. Lab. Animal Care *14*:314, 1964. Abstr., Proc. Animal Care Panel Meeting, New York, September 23, 1964.

7. Shellenberger, T.E., J.M. Lee, B.P. Udale, and G.W. Newell. **The comparative toxicity of DDT, dieldrin, and heptachlor to Japanese and Bobwhite quail.** Presented at Soc. Toxicol. Fifth Annual Meeting, Williamsburg, VA, March 14-l 6, 1966.

8. Jorgenson, T.A., G.W. Newell, R.J. Spanggord, D.L. Kay and P.L. Gribling. **Mutagenic activity of triethylenemelanine administered orally in the diet and drinking water.** Presented at Environ. Mutagen Soc. Fifth Annual Meeting, Washington, DC, March 10, 1974.

9. Simmon, V.F., G.W. Newell, and T.A. Jorgenson. **Study of the mutagnic effects of monosodium glutamate.** NTIS publication: PB 269 573/2GA, April 1974, National Technical Information Service, Springfield, VA.

10. Jorgenson, T.A., G.W. Newell, and P. Gribling. **Study of the mutagenic potential of the moncalcium salt of nitrilotriacetic acid (NaCaNTA) by the dominant lethal test in mice**. Presented at Soc. of Toxicol. Fourteenth Annual Meeting, Williamsburg, VA, March 9, 1975.

11. Jorgenson, T.A., G.W. Newell, and L.G. Scharpf. **Study of the mutagenic potential of nitrilotriacetic acid (NaCaNTA) in mice by the translocation test**. Presented at Environ. Mutagen Soc. Sixth Annual Meeting, Miami Beach, FL, May 9, 1975.

12. Jorgenson, T.A., C.J. Rushbrook, and G.W. Newell. **In vitro mutagenesis investigations of ten commercial pesticides**. Presented at Soc. of Toxicol. Fifteenth Annual Meeting, Atlanta, GA, March 16, 1976.

13. Newell, G.W., T.A. Jorgenson, C.J. Rushbrook, and R.J. Spanggord. **Preliminary investigations of new orally active reference mutagens**. Presented at the Soc. of Toxicol. Fifteenth Annual Meeting, Atlanta, GA, March 16, 1976.

14. Poole, D.C., G.W. Newell and V.F. Simmon. **In vitro mutagenic studies of twenty pesticides.** Presented at Soc. of Toxicol. Fifteenth Annual Meeting, Atlanta, GA, March 14-18, 1976.

15. Jorgenson, T.A., G.W. Newell, D.P. Sasmore and C.J. Rushbrook. **Acute and subacute toxicity studies of a new artificial sweetener**. Presented at Soc. of Toxicol. Fifteenth Annual Meeting, Atlanta, GA, March 14-18, 1976.

16. Jorgenson, T.A., C.J. Rushbrook, G.W. Newell, and S. Green. **Study of the mutagenic potential of three GRAS chemicals in mice by the heritable translocation test.** Presented at Environ. Mutagen Soc. Eighth Annual Meeting, Colorado Springs, CO, February 16, 1977.

17. Simon, V.F., S.L. Echford, A.F. Griffin, R.J. Spanggord, and G.W. Newell. **Do bacteriocidal treatments produce microbial mutagens?** Presented at Soc. of Toxicol. Sixteenth Annual Meeting, Toronto, Canada, March 27-30, 1977.

18. Jorgenson, T.A., C.J. Rushbrook, G.W. Newell, and S. Green. **In vivo mutagenesis investigations of four GRAS chemicals.** Presented at Second lntrnatl. Conf. on Environ. Mutagens, Edinburgh, Scotland, July 11, 1977.

19. Jorgenson, T.A., C.J. Rushbrook, G.W. Newell, and S. Green. **A study of the mutagenic potential of N-methyl-nitro-nitroso-guanidine (MNNG) in mice by the translocation test**. Presented at Second lntrnatl. Conf. on Environ. Mutagens, Edinburgh, Scotland, July 11, 1977.

20. Jorgenson, T.A., C.J. Rushbrook, G.W. Newell, and M. Waters. **Study of the mutagenic potential of Captan by the heritable translocation test in mice.** Presented at Second Intrnatl. Conf. on Environ. Mutagens, Edinburgh, Scotland, July 11, 1977.

21. Hill, J.T., T.A. Jorgenson, V.F. Simmon, G.W. Newell, and D.J. Brusick. **Mutagenic evaluation of carboxy-methyltartronate, a non-phosphate builder for heavy duty laundry detergents.** Presented at Environ. Mutagen Soc. Ninth Annual Meeting, San Francisco, CA, March 12, 1978.

22. Newell, G.W. **The quality, treatment and monitoring of water for laboratory rodents.** Lab. Animal Sci. *30*:377-384, April 1980, Part Il.

23. Newell, G.W. **Introductory Comments to the symposium on the Future of Animals in Research and Teaching.** Presented at 22nd Annual Meeting of the Soc. of Toxicol., Las Vegas, NV. Fundamental and Appl. Tox. *4*:503-504 (1984).

24. Newell, G.W. **The role of risk assessment in United States regulatory decisions.** Environ. Sci. Res. *31*:771-785 (1984).

Major Reviews and Book Chapters

1. Newell, G.W. **Animal sampling techniques**, section of Chapter X, Sampling techniques. In Air Pollution Handbook, P.L. Magill (ed.), McGraw-Hill Book Co., New York, 1956.

2. Generoso, W.M., J.B. Bishop, D.G. Gosslee, G.W. Newell, C. Sheu, and E. VonHalle. **Heritable translocation test in mice**: **A report of the "Gene-Tax" program.** Reviews in Genetic Toxicol. *76:*191-215, 1980.

3. Newell, G.W. **Overview of Formaldehyde** in Formaldehyde Toxicity, J.E. Gibson, E. pp. 3-12. Hemisphere Publishing Corp, New York (1983).

4. Heddle, J.A., M. Hite, B. Kirkhart, K. Mavoumin, J.T. MacGregor, G.W. Newell and M.F. Salamone . **The induction of micronuclei as a measure of genotoxicity**. A report of USEPA Gene-Tox Program. Mutation Res. *123*:61-l 18 (1983).

Other Publications

General

1. Newell, G.W. **New and improved food additives**. Activities Report, Research and Development Associates, Food and Container Institute *14*:204, 1962.

2. Newell, G.W. **Food additives of tomorrow**. Food Processing *24*:70, 1963.

3. Newell, G.W. and W.A. Maxwell. **Chemical mutagenesis and the safety of man**. Life Sciences Res. Report, Stanford Res. Inst. *5*, No. 1, 5pp, 1973.

4. Maibach, H.I., and G.W. Newell**. Oral use of topical silver nitrate: carcinogenic potential unproved**. J. Am. Med. Assoc. *244*(8):835, August 22/29, 1980.

PERSONAL

Business address:	Gordon W. Newell, Ph.D., F.-A.T.S. CONSULTANTS IN TOXICOLOGY General and Environmental Toxicology 4163 Hubbartt Drive Palo Alto, CA 94306-3834 (415)-494-7751
FAX	(415)-494-7751
Home address:	4163 Hubbartt Drive Palo Alto, CA 94306-3834 (415) 493-6537

March, 1995

CURRICULUM VITAE

Dr. John W. Erdman, Jr.
Professor
University of Illinois
Division of Nutritional Sciences
451 Bevier Hall, 905 S. Goodwin
Urbana, IL 61801

Office Phone: 217-333-2527
217-333-4177
e-mail: jwerd@uiuc.edu
Home Phone: 217-384-5044

Born: July 7, 1945, hackensack, New Jersey; Married, two children

Training and Experience: Nutritional and physiological biochemistry of man and animal; bioavailability of nutrients in foods; vitamin A and β-carotene metabolism; nutrient retention in foods during processing; soy protein and lipid metabolism.

Education:

BS	1968	Rutgers University	Food Science
MS	1973	Rutgers University	Food Science
M. Phil.	1974	Rutgers University	Food Science
PhD	1975	Rutgers University	Food Science

Employment:

1991 - present	Director, Division of Nutritional Sciences
1991 - present	Assistant Director, Agricultural Experimant Station
1989 - 1991	Interim Director, Division of Nutritional Sciences
1989 - 1991	Acting Assistant Director, Agricultural Experiment Station
8/85 - present	Professor of Food Science; Professor of Nutritional Sciences; Professor of Nutrition in Internal Medicine, University of Illinois
8/80 - 8/85	Associate Professor, University of Illinois
1979 - 1991	Coordinator, Chicago Extramural Master of Science in Food Science
4/75 - 8/80	Assistant Professor, University of Illinois
9/70 - 5/75	Research Assistant, Research Intern & Lecturer in varios Food Science courses, Rutgers University
10/68 - 8/70	US Army, Plt. Leader & Company Commander, Combat Engineers, USA and Vietnam
5/68 - 10/68	Pepsico (Corporate Research) Flavor Chemistry

Courses Taught: Nutrition and Food Chemistry; Biochemical Aspects of Nutrition; Introductory Food Science; Lectures in a graduate level Current Topics in Nutrition Research; Vitamin A and ß-carotene Metabolism; Nutrition Lectures for medical students.

Professional Societies and Committee Assignments:

American Institute of Nutrition 1980

1986-1989	Nominating Committee, Borden Award in Nutrition (Chair, 88-89)
1987-present	Various Awards Juries
1989-1990	Task Force on Nutritional Labeling
1989-1993	Program Planning Committee (Chair, Annual Meeting 1992, 1993)
1990-1991	Nomination Committee
1989-1992	Outside Awards Committee
1989-1992	Intersociety Program Committee (FASEB)
1992-1997	Experimental Biology Program Committee
1991-1994	Finance Committee
1992-1995	Councilor
1994-1995	Strategic Planing Committee

Institute of Food Technologists 1979

1973-1975	Member, Borard of Directors, NY Section
1974-1975	Coordinator, Undergraduate Research Paper Competition, Student Division, IFT
1974-1976	Alternate Counselor from NY Section to National IFT
1979-1982	National Annual Meeting Program Committee
1980-1985	Continuing Education Committee - Chicago Section
1980-1982	Executive Committee - Chicago Section
1982-1985	IFT Scientific Lectureship Committee, Chairman 1984-1985
1983-1995	Councilor from Chicago Section
1983-1985	Long-Range Planning Committee (National)
1983-1986	IFT Awards Jury
1985-1988	Councilor Representative to Executive Committee
1986-1995	Expert Panel of Food Safety and Nutrition
1990-1992	Alternate Regional Communicator
1992-1995	Committee on Nominations and Elections, Chairman, 1994-95

Sigma Xi 1975

Phi Tau Sigma 1975

American Association of Cereal Chemists 1976

1979-1980	Ad Hoc Advisory Study Group on Nutrition

Agricultural and Food Chemistry Division of American Chemistry Society 1980

American Oil Chemists Society 1978

Illinois Nutrition Association 1988.

National Academy of Science Committee:

1981-1985	Subcommittee on Uses of the RDA, Food and Nutrition Board, National Research Council
1987-1990	Vice Chairman, Committee on Food Additives Survey Data, Food and Nutrition Board, National Research Council

1988-1992	Member, Subcommittee on Bioavailability of Nutrients, Committee on Animal Nutrition, Board on Agriculture
1989-1990	Member, Committee on Nutrition Components of Food Labeling, Institute of Medicine
1991-1992	Member, Committee on State Food Labeling, Institute of Medicine
1991-1993	Vice-chair, Committee on Opportunities in Nutrition & Food Science, Institute of Medicine
1990-1997	Member, Food and Nutrition Board, Institute of Medicine; Vice-chair 1993-96
1996-1997	Member, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes

Editorial Boards:

1982-1985	Board of Editors, *Journal of Food Science*
1983-1986	Board of Editors, *Cereal Chemistry*
1986-1993	Editorial Board, *Plant Foods for Human Nutrition*
1988-1993	Editorial Board, *The Journal of Nutrition* (Associate Editor, 1990-91)
1986-present	Advisory Board, *Nutrition Research Newsletter*
1987-present	Advisory Board, *CRC Critical Reviews in Food Science and Nutrition*
1991-present	Editorial Advisory Board, *Guide to U.S. Food Labeling Law*
1991-present	Editorial Board, *Antioxidants Vitamin Newsletter*

Honors and Awards:

1977-present	List of Teachers Ranked Excellent or Outstanding at the University of Illinois (eight times)
1980	Samuel Cate Prescott Award for Research-Institute of Food Tech.
1980-1985	Monthly Columnist in Cereal Foods World "Nutrition Notes" Column
1981, 84, 90, 94	USDA, Panel Member, Competitive Research Grant Review in Human Nutrition
1982-1985	Scientific Lecturer, Institute of Food Technologists
1982-1992	Scientific Advisory Committee, American Institute of Baking
1982-1986	Nutrition Advisor to the Wheat Industry Council
1983	Excellence in Off-Campus Teaching Award, University of Illinois
1984-1985	Chairman, Nutrition Division of IFT
1985	Outstanding Academic Advisor, The Agriculture Council, College of Agriculture, University of Illinois
1986-1989	Soybean Utilization Advisory Panel, American Soybean Assn.
1986	Wm. V. Cruess Award, for Teaching, Institute of Food Technologists
1986	Paul Funk Award, College of Agriculture, University of Illinois
1986-1987	Visiting Professor, Biochemistry and Biophysics Department, Iowa State University with James A. Olson, PhD
1988	Chairman's Achievement Award, Chicago Section of IFT
1989	Distinguished Phi Tau Sigma Lecturer, North Carolina State Univ.

1991	Co-winer American Soybean Assn. Soybean Research Team Recognition Award
1992	Philadelphia Section, IFT, Lectureship Award
1992	Elected Fellow of Institute of Food Technologists
1992	Member, Food Advisory Committee, Subcommittee on Folic Acid, FDA
1993-1996	Member, CARIG (Carotenoid Investigative Group) Steering Committee
1994	Outstanding Faculty Award, Nutritional Sciences Graduate Student Assn. U of I
1994	Borden Award, American Institute of Nutrition
1995	Vice-chair, Gordon Conference on Carotenoids
1995-1998	Member, Food, Nutrition & Safety Committee, ILSI-NA
1998	Chair, Gordon Conference on Carotenoids

Publications
John W. Erdman, Jr.

Books and Supplements (authored or edited):

Labuza, T.P. and J.W. Erdman, Jr. 1984. Food Science and Nutritional Health: An Introduction. West Publ. Company, Inc., St. Paul, MN, 550 pgs.

Bodwell, C.E. and J.W. Erdman, Jr. (Eds). 1988. Nutrient Interactions. Marcel Dekker, Inc., NY, NY, 408 pgs.

Williams, G.M., H. Sies, J.W. Erdman, Jr., G.T. Baker III and C.J. Henry. 1993. Antioxidants: Chemical, Physiological, Nutritional and Toxicological Aspects. Princeton Scientific Publ. Inc., Princeton, NJ 387 pgs.

Labuza, T.P. and J.W. Erdman, Jr. 1997 Food Science and Nutritional Health: An Introduction. (Second Edition) West Publ. Company, Inc., St. Paul, MN (in preparation).

Messina, M. and J.W. Erdman, Jr. (Guest Editors) 1995. Proceedings of the First International Symposium on Soy Foods and Chronic Disease Prevention. J. Nutr. 125(3S): 563-808S.

Erdman, J.W., Jr. (Guest Editor) 1995. 1994 AIN Symposium Proceedings. J. Nutr. 125(6S): 1633-1808S.

Journal Publications (original research publications):

1. Erdman, J.W., Jr., S.H. Hou and P.A. Lachance. 1973. Fluorometric determination of vitamin A in foods. J. Food Sci. 31:447-449.

2. Erdman, J.W., Jr. and P.A. Lachance. 1974. Effect of salt mixture and cholesterol upon rat serum and liver zinc, vitamin A, and cholesterol. Nutr., Repts Intern. 9:319-329.

3. Erdman, J.W., Jr. and P.A. Lachance. 1974. Failure of the non-vitamin A active carotenoid lycopene to act as an antihypercholesterolemic agent in rats. Nutr. Repts. Intern. 11:227-284.

4. Erdman, J.W., Jr. 1975. The effect of vitamin A upon the *in vitro* synthesis of cholestesrol. PhD Thesis, Rutgers University, New Brunswick, NJ.

5. Erdman, J.W., Jr., M.P. O'Connor, K.E. Weingartner, L.W. Solomon, and A.I. Nelson. 1977. Production, nutritional value and baking quality of soy-egg flours. J. Food Sci. 42:964-968.

6. Erdman, J.W., Jr., J. Elliot and P.A. Lachance. 1977. Effect of retinoic acid upon Mevalonic Acid-2-14C incorporation into lipids in an isolated rat liver fraction. Nutr. Repts. Intern. 16:37-46.

7. Erdman, J.W., Jr., J. Elliot and P.A. Lachance. 1977. The effect of three forms of vitamin A upon *in vitro* lipogenesis from three cholesterol precursors. Nutr. Repts. Intern. 16:47-57.

8. Bankhead, R.R., K.E. Weingartner, D.A. Kuntz and J.W. Erdman, Jr. 1978. The effects of sodium bicarbonate blanching on the retention of micronutrients in soymilk. J. Food Sci. 43:345-348, 360.

9. Erdman, J.W., Jr. And T.C. O'Reilly. 1978. Hypercholesterolemia in rats fed cholesterol in agar gel diets. Lipids 13:588-593.

10. O'Connor, M.P., J.W. Erdman, Jr. and A.I. Nelson. 1979. Baking characteristics and protein quality of soy-whole egg, soy-egg yolk and soy-egg white supplemented breads. J.Food Sci. 44:839-842.

11. Weingartner, K.E., J.W. Erdman, Jr., H.M. Parker and R.M. Forbes. 1979. The effect of soybean hull upon the bioavailability of zinc and calcium from soy flour-based diets. Nutr. Repts. Intern. 19(2):223-231.

12. Gerber, L.E. and J.W. Erdman, Jr. 1979. Effect of retinoic acid and retinyl acetate feeding upon lipid metabolism in adrenalectomized rats. J. Nutr. 109:580-589.

13. Forbes, R.M., K.E. Weingartner, H.M. Parker, R.R. Bell and J.W. Erdman, Jr. 1979. Bioavailability of zinc, magnesium, and calcium in soy protein diets. J. Nutr. 109:1652-1660.

14. Solomon, L.W. and J.W. Erdman, Jr. 1980. Vitamin A induced hypertriglyceridemia in the serum of cholesterol-fed rats. Lipids 15:157-162.

15. Gerber. L.E. and J.W. Erdman, Jr. 1980. Comparative effects of all-trans and 13-cis retinoic acid administration on serum and liver lipids in rats. J. Nutr. 110:343-351.

16. Erdman, J.W., Jr., K.E. Weingartner, G.C. Mustakas, R.D. Schmutz, H.M. Parker and R.M. Forbes. 1980. Zinc and magnesium bioavailability from acid precipitated and neutralized soybean protein products. J. Food Sci., 45:1193-1199.

17. Hildebrand, D.F., N.S. Hettiarachchy, T. Hymowitz and J.W. Erdman, Jr. 1981. Electrophoretic separation and properties of winged bean seed trypsin inhibitor. J.Sci. of Food Agri. 32:443-450.

18. Erdman, J.W., Jr. 1981. Bioavailability of trace minerals from cereals and legumes. Cereal Chem. 58:21-26.

19. Kinney, C.L., L.E. Gerber and J.W. Erdman, Jr. 1981. Absorption efficiency of vitamin A from agar gel diets. Nutr. Repts. Intern. 23:143-150.

20. Gerber, L.E. and J.W. Erdman, Jr. 1981. Hyperlipidemia in rats fed retinoic acid. Lipids 16:496-501.

21. Weingartner, K. E., L. Franzen and J.W. Erdman, Jr. 1981. Effect of coprophagy in rats upon bioavailability of calcium added to casein-and soy flour-based diests. Nutr. Repts. Intern. 23:755-761.

22. Baker, E.C., Mustakas, G.C., Erdman, J.W., Jr. and L.T. Black. 1981. The preparation of soy products with different levels of native phytate for zinc bioavailability studies. J. Am. Oil Chem. Soc. 58:541-543.

23. Thompson, D.B. and J.W. Erdman, Jr. 1982. Phytic acid determination in soybeans. J. Food Sci. 47:513-517.

24. Gerber, L.E., L.S. Wasserman, B.H.S. Cho and J.W. Erdman, Jr. 1981. Changes in serum triglycerides, retinoic acid, and retinol associated with withdrawal of retinoic acid from diets of rats. Nutr. Res. 1:509-517.

25. Hargett, C.A., A.I. Nelson, K.E. Weingartner and J.W. Erdman, Jr. 1982. Development, utilization and protein quality of potato: soy: egg flours. J. Food Sci. 47:461-464.

26. Gerber, L.E. and J.W. Erdman, Jr. 1982. Effect of dietary retinyl acetate, β-carotene and retinoic acid upon wound healing in rats. J. Nutr. 112:1555-1564.

27. Farris, W.A. and J.W. Erdman, Jr. 1982. Protracted hypervitaminosis A following long term daily intake of 50,000 IU of vitamin A. J. Am. Med. Assn. 247:1317-1318.

28. Thompson, D.B. and J.W. Erdman, Jr. 1982. A structural model for "Ferric Phytate": Implications for phytic acid analysis. Cereal Chem. 59:525-528.

29. Weingartner, K.E., A.I. Nelson and J.W. Erdman, Jr., 1983. Addition of calcium citrate and tricalcium phosphate to soy beverage. J. Food Sci. 48:256-263.

30. Forbes, R.M., J.W. Erdman, Jr. H. Parker, H. Kondo and S.M. Ketelson. 1983. Bioavailability of zinc coagulated soy protein (tofu) to rats and effect of dietary calcium at a constant phytate/zinc ratio. J. Nutr. 113:205-210.

31. Grummer, M.A. and J.W. Erdman, Jr. 1983. Effect of chronic alcohol consumption and moderate fat diet on vitamin A status in rats fed either vitamin A or β-carotene. J. Nurt. 113:350-364.

32. Broich, C.R., L.E. Gerber and J.W. Erdman, Jr. 1983. Determination of lycopene, α-and β-carotene and retinyl esters in human serum by reverse-phase high-performance liquid chromatography. Lipids 18:253-258.

33. Sri kantha, S., N.S. Hettiarachchy and J.W. Erdman, Jr. 1983. Laboratory scale production of winged bean curd (tofu). J. Food Sci. 48:441-444.

34. Weingartner, K.E. and J.W. Erdman, Jr. 1983. Coprophagy prevention in rats by conditioning with lithium chloride. Nutr. Repts. Intern. 27:357-364.

35. Weingartner, K.E., W.L. Heckt and J.K. Erdman, Jr. 1983. Effect of coprophagy prevention in rats on zinc bioavailability from soy flour. Nutr. Repts. Inter. 27:365-370.

36. Forbes, R.M., H. Parker, H. Kondo, and J.W. Erdman, Jr. 1983. Availability to rats of zinc in green and mature soybeans. Nutr. Res. 3:699-704.

37. Thompson, D.B. and J.W. Erdman, Jr. 1984. The effect of soy protein isolate in the diet on retention by the rat of iron from radiolabeled test meals. J. Nutr. 114:307-311.

38. Ketelson, S.M., M.A. Stuart, C.M. Weaver, R.M. Forbes and J.W. Erdman, Jr. 1984. Bioavailability of zinc from defatted soy flour, acid-precipitated soy concentrate and neutralized soy concentrate as determinated by intrinsic and extrinsic labeling techniques. J.Nutr. 114:536-542.

39. Hettiarachchy, N.S. and J.W. Erdman, Jr. 1984. Bioavailability of zinc and iron from mature winged bean seed flour. J. Food Sci. 49:1132-1135,1142.

40. Forbes, R.M., H.M. Parker and J.W. Erdman, Jr. 1984. Effects of dietary phytate, calcium, and magnesium levels on zinc bioavailability in rats. J. Nutr. 114:1421-1425.

41. Cho, B.H.S., J.W. Erdman, Jr. and J.E. Corbin. 1984. Effects of feeding raw eggs on plasma and lipoprotein cholesterol in dogs. Nutr. Repts. Intern. 30(1):163-170.

42. Kazanas, N., R.W. Ely, M.L. Fields and J.W. Erdman, Jr. 1984. Effects of fermented and unfermented sorghum meal diets naturally contaminated with mycotoxins. Appl. and Envir. Microbiol. 47:1118-1125.

43. Picciano, M.F., K.E. Weingartner and J.W. Erdman, Jr. 1984. Relative bioavailability of dietary iron from three processed soy products. J. Food Sci. 49:1558-1561.

44. Tervola, KMU, M.A. Grummer, J.W. Erdman, Jr. and W.D. O'Brien, Jr. 1985. Utrasonic attenuation and velocity properties in rat liver as a function of fat concentration—a study at 100 MHz using a scanning laser acoustic microscope. J. Acoust. Soc. Am. 77:307-313.

45. Curran-Celentano, J., J.W. Erdman, R.A. Nelson and S.J.E. Grater. 1985. Alterations in vitamin A and thyrod hormone status in anorexia nervosa and associated disorders. Am. J. Clin. Nutr. 42:1183-1191.

46. Thompson, D.B. and J.W. Erdman, Jr. 1985. The effect of diet in retention by the rat of iron from a radiolabeled casein test meal. J. Nutr. 115:319-326.

47. Grummer, M.A. and J.W. Erdman, Jr. 1986. Effect of chronic alcohol consumption and moderate or high fat diet upon tissue distribution of vitamin A or β-carotene. Nutr. Res. 6:61-73.

48. Sri Kantha, S., N.S. Hettiarachchy and J.W. Erdman, Jr. 1986. Nutrient, and anti-nutrient contents and solubility profiles of nitrogen, phytic acid and selected mineral in winged bean meal. Cereal Chem. 63:9-13.

49. Stuart, M.A., S.M. Ketelson, C.M. Weaver and J.W. Erdman, Jr. 1986. Bioavailability of zinc to rats as affected by protein source and previous dietary intake. J. Nutr. 116:1423-1431.

50. Erdman, J.W., Jr., G.C. Fahey and C.B. White. 1986. Effects of purified dietary fiber sources on β-carotene utilization by the chick. J. Nutr. 116:2415-2423.

51. Poor, C.L., S.D. Miller, G.C. Fahey, R.A. Easter and J.W. Erdman, Jr. 1987. Animal models for carotenoid utilization studies: Evaluation of the chick and the pig. Nutr. Repts. Intern. 36:229-234.

52. Fordyce, E.J., R.M. Forbes, K.R. Robbins and J.W. Erdman, Jr. 1987. Phytate x calcium/zinc molar ratios: Are they predictive of zinc bioavailability? J. Food Sci. 52:440-444.

53. Poneros, A.G. and J.W. Erdman, Jr. 1988. Bioavailability of calcium from tofu, tortillas, mozzarella cheese and non-fat dry milk: Effect of ascorbic acid. J. Food Sci. 53:208-210, 230

54. Thompson, D.B. and J.W. Erdman, Jr. 1988. Effect of various soy protein products on retention of non heme iron from a casein test meal or from soy-based test meals. J. Food Sci. 53:1460-1463, 1469.

55. Sri Kantha, S. and J.W. Erdman, Jr. 1988. Effects of different heat treatments of winged bean seed flour on nutritional status of rats. Nutr. Repts. Intern. 38:423-435.

56. O'Brien, W.D., Jr., Hebner, T. and Erdman, J.W., Jr. 1988. Ultrasonic propagation properties (at 100 MHz) in excessively fatty rat liver. J. Acoust. Soc. Am. 83(3):1159-1166.

57. Dietz, J.M. Sri Kantha, S. and J.W. Erdman, Jr. 1988. Reverse phase HPLC analysis of α- and β-carotene from selected raw and cooked vegetables. Plant Foods for Human Nutr. 38:333-341.

58. Poneros-Schneier, A.G. and J.W. Erdman, Jr. 1989. Bioavailability of calcium from sesame seeds, almond powder, whole wheat bread, spinach and nonfat dry milk in rats. J. Food Sci. 54:150-153.

59. Schmitz, H.H., W.E. Artz, C.L. Poor, J.M. Dietz and J.W. Erdman, Jr. 1989. HPLC and capillary SFC separation of vegetable carotenoids and carotenoid isomers. J. Chromatography 479:261-268.

60. Garcia-Lopez, J.S., Erdman, J.W., Jr. and A.R. Sherman. 1990. Iron retention from casein-legume test meals: Effect of tannin level and previous diet. J. Nutr. 120:760-766.

61. Artz, W.E., C.C. Warren, J.W. Erdman, Jr. and R. Villota. 1990. The nutritional properties of extruded and non-extruded corn fiber isolate. Plant Foods for Human Nutr. 40:95-98.

62. Tanumihardjo, S.A., H.C. Furr, J.W. Erdman, Jr. and J.A. Olson. 1990. Use of the modified relative dose response (MRDR) assay in rats and its application in humans for the measurement of vitamin A status. European J. Clin. Nutr. 44:219-224.

63. Chung, T.K., J.W. Erdman, Jr. and D.H. Baker. 1990. Hydrated sodium calcium aluminosalicate: Effects on zinc, manganese, vitamin A and riboflavin utilization. Poultry Sci. 69:1364-1370.

64. Tiernan, P.J., McCauley, K., Hebner, T., Erdman, J.W., Jr. and W.D. O'Brien, Jr. 1990. Ultrasonic propagation properties (at 100 MHz) in liver of rats exposed to ethanol or carbon tetrachloride. Annual International Conference of IEEE Engineering in Medicine & Biology Society 12(1):297-300.

65. Schmitz, H.H., C.L. Poor, R.B. Wellman and J.W. Erdman, Jr. 1991. Concentrations of selected carotenoids and vitamin A in human liver, kidney and lung tissue. J. Nutr. 121:1613-1621.

66. Bruns, N.J., E.T. Gugger, P.V. Johnston and J.W. Erdman, Jr. 1991. The relationship between plasma, leukocyte and leukocyte membrane beta-carotene concentrations in bovine animals. Nutr. Res. 11:643-648.

67. Peterson, C.A., J.C. Eurell and J.W. Erdman, Jr. 1992. Bone composition and histology of young growing rats fed diets of varying calcium bioavailability, spinach, nonfat dry milk, or CaCo3 added to casein. J. Nutr. 122:137-144.

68. Gugger, E.T., T.L. Bierer, T.M. Henze, W.S. White and J.W. Erdman, Jr. 1992. β-carotene uptake and tissue distribution in the ferret (*Mustela putorius furo*) J. Nutr. 122:115-119.

69. Poor, C.L., T.L. Bierer, N.R. Merchen, G.C. Fahey, Jr., M.R. Murphy and John W. Erdman, Jr. 1992. Evaluation of the preruminant calf as a model for study of human carotenoid metabolism. J. Nutr. 122:262-268.

70. Bryant, J.D., J.D. McCord, L.K. Unlu and J.W. Erdman, Jr. 1992. The isolation and partial characterization of α & β-carotene carotenoprotein(s) from carrot (*Daucus carota L*) root chromoplasts. J. Ag. Food Chem. 40:545-549.

71. Chapman, K., M. Prabhudesai and J.W. Erdman, Jr. 1992. Effects of ethanol and carbon tetrachloride upon vitamin A status of rats. Alcoholism: Clinical and Experimental Research 16(4):764-768.

72. Zhou, J.R., E.J. Fordyce, V. Raboy, D.B. Dickinson, M.S. Wong, R.A. Burns and J.W. Erdman, Jr. 1992. Reduction of phytic acid in soy products improves zinc bioavailability in rats. J. Nutr. 122:2466-2473.

73. Chapman, K. McCauley, J.W. Erdman, Jr. and M. Prabhudesai. 1993. Vitamin A status of alcoholics upon admission and after two weeks of hospitalization. J. Am. College Nutr. 12:77-83.

74. White, W.S., K.M. Peck, E.A. Ulman and J.W. Erdman, Jr. 1993. The ferret as a model for evaluation of the bioavailability of all-trans-β-carotene and its isomers. J. Nutr. 123:1129-1139.

75. Curran-Celentano, J. and J.W. Erdman, Jr. 1993. A case study of carotenemia in anorexia nervosa may support the interrelationship of vitamin A and thyroid hormone. Nutr. Res. 13:379-385.

76. Glore, S.R., V.L. Orth, A.W. Khehans, and J.W. Erdman, Jr. 1993. Efficiency of dietry zinc supplementation on catch-up growth after protein malnutrition. J. Nutr. Biochem. 4:281-285.

77. Potter, S.M., R. Bakhit, D. Essex-Sorlie, K. Weingartner, K. Chapman, R. Nelson, M. Prabhudesai, W. Savage, A.I. Nelson, L. Winter and J.W. Erdman, Jr. 1993. Depression of plasma cholesterol in mildly hypercholesterolemic men by consumption of baked products containing soy protein. Am. J. Clin. Nutr. 58:501-506.

78. Chapman, K. McCauley, M. Prabhudesai and J.W. Erdman, Jr. 1993. Effects of acute ethanol doses and dietary phenobarbitol with carbon tetrachloride exposure upon vitamin A status of rats. Alcoholism: Clin Exp. Res. 17:637-642.

79. White, W.S., K.M. Peck, T.L. Bierer, E.T. Gugger, & J.W. Erdman, Jr. 1993. Interactive effects of oral β-carotene and canthanxanthin in ferrets. J. Nutr. 123:1405-1413.

80. Zhou, J.R., M.M. Canar and J.W. Erdman, Jr. 1993. Bone zinc is poorly released in young, growing rats fed marginally zinc restricted diet. J. Nutr. 123:1383-1388.

81. Poor, C.L., T.L. Bierer, N.R. Merchen, G.C. Fahey, Jr. and J.W. Erdman, Jr. 1993. The accumulation of α- and β-carotene in serum and tissues of preruminant calves fed raw and steamed carrot slurries. J. Nutr. 123:1296-1304.

82. Ham, J.O., K.M. Chapman, D. Essex-Sorlie, R.M. Bakhit, M. Prabhudesai, L. Winter, J.W. Erdman, Jr. and S.M. Potter. 1993. Endocrinological response to soy protein and fiber in mildly hypercholesterolemic men. Nutr. Res. 13:873-884.

83. Glore, S.R., Orth, V.L., Stoecker, B.J., Khehans, A.W. and J.W. Erdman, Jr. 1993. Dietary zinc supplements do not enhance catch-up growth of rats during recovery from protein-zinc malnutrition when the diets are based on either isolated soybean protein or casein. Nutr. Res. 13:1025-1038.

84. White, W.S., K.M. Peck, E.A. Ulman and J.W. Erdman, Jr. 1993. Evaluation of the bioavailability of natural and synthetic forms of β-carotene in a ferret model. In: *Carotenoids in Human Health*, (Eds.) L.M. Canfield, N.I. Krinsky and J.A. Olson, Annals of the New York Academy of Sciences, New York, 691:229-231.

85. Bierer, T.L., N.R. Merchen, D.R. Nelson and J.W. Erdman, Jr. 1993. Transport of newly-absorbed beta carotene by the preruminant calf. In: *Carotenoids in Human*

Health, (Eds.) L.M. Canfield, N.I. Krinsky and J.A. Olson, Annals of the New York Academy of Sciences, New York, 691:226-228.

86. Burri, B. J., Z.R. Dixon, A.K. Fong and J.W. Erdman, Jr. 1993. Possible association of skin lesions with a low carotene diet in premenopausal women. In: *Carotenoids in Human Health*, (Eds.) L.M. Canfield, N.I. Krinsky and J.A. Olson, Annals of the New York Academy of Sciences, New York, 691:279-280.

87. Bakhit, R.M., S.M. Potter, B.P. Klein, D. Essex-Sorlie and J.W. Erdman, Jr. 1994. Intake of 25 g soy protein with or without soy fiber alters plasma lipids in men with elevated cholesterol concentrations. J. Nutr. 124:213-222.

88. Pollack, J., Campbell, J.M., S.M. Potter and J.W. Erdman, Jr. 1994. The Mongolian gerbil (*meriones unguiculalus*) absorbs β-carotene intact from a test meal. J. Nutr. 124:869-873.

89. Dixon, Z.R., B.J. Burri, A. Clifford, E.N. Frankel, B.O. Schneeman, E. Parks, N.L. Keim, T. Barbieri, M-M. Wu, A.K.H. Fong, M.J. Kretsch, A.L. Sowell and J.W. Erdman, Jr. 1994. Effects of a carotene-deficient diet on measures of oxidative susceptibility and superoxide dismutase activity in adult women. Free Rad. Biol. Med. 17:537-544.

90. White, W.S., M. Stacewicz-Sapuntzakis, J.W. Erdman, Jr. and P. Bowen. 1994. Pharmacokinetics of β-carotene and canthaxanthin after ingestion of individual and combined doses by human subjects. J. Am. Col. Nutr. 13:665-671.

91. Zhou, J.R., E.T. Gugger and J.W. Erdman, Jr. 1994. Isolation and partial characterization of an 18 KDa cartenoid-protein complex from carrot roots. J. Ag. Food Chem. 42:2386-2390.

92. Peterson, C.A., Eurell, J.C., Kelley, K.W. and J.W. Erdman, Jr. 1995. Bone composition and histologic analysis of young and aged rats fed diets of varied calcium bioavailability. J. Am. Col. Nutr. 14:278-285.

93. Holman, R.T., Adams, C.E., J.W. Erdman, Jr., R.A. Nelson, S.J.E. Grater, J.A. Jaskiewicz and S.B. Johnson. 1995. Deficiencies of polyunsaturated fatty acids compensatory changes in non-essential fatty acids in relative to fluidity of plasma lipids in anorexia nervosa. J. Nutr. 125:901-907.

94. Alekel, L., J.L. Clasey, P. Fehling, R.M. Weigel, R.A. Boileau, J.W. Erdman, Jr. and R. Stillman. 1995. Contributions of exercise, body composition, and age to bone mineral density in premenopausal women. Med. & Sci. in Sports & Exercise 27:1477-1485.

95. Peterson, C.A., J.C. Eurell and J.W. Erdman, Jr. 1995. Alterations in calcium intake and attainment of peak bone mass in the female rat. J. Bone Mineral Res. 10:81-95.

96. Bierer, T.L., N.R. Merchen and J.W. Erdman, Jr. 1995. Comparative absorption and transport of five common carotenoids in the preruminant calf. J. Nutr. 125:1569-1577.

97. Zhou, J.R. and J.W. Erdman, Jr. 1996. The crystalline form of carotenes, and the food matrix in carrot root decrease the relative bioavailability of beta and alpha carotene in ferrets. J. Am. Coll. Nutr. 15: (in press).

98. Peterson, C.A., D.H. Baker and J.W. Erdman, Jr. 1996. Dietary-induced nephrocalcinosis in female rats is nonreversible and is inducible only during the rapid growth period. J. Nutr. (in press).

99. Liao, C.H., J.W. Erdman, Jr., E.W. Voss, Jr. and P.V. Johnston. 1996. Dietary vitamin A deficiency and the immune system of a murine model of systemic lupus erythematosus (SLE). Nutr. Res. (in press).

100. Gugger, E.T. and J.W. Erdman, Jr. 1996. Intracellular proteins β-carotene transport in bovine liver and intestine is not mediated by cytosolic proteins. J. Nutr. (in press).

101. Balmir, F., R.M. Bakhit, J.W. Erdman, Jr. and S.M. Potter. 1996. Intake of 25 g soy protein does not alter plasma hoormonal conentrations in mildly hypercholesterolemic men. Nutr. Res. (submitted).

102. Clinton, S.K., C. Emenhiser, S. Schwartz, D.G. Bostwick, A.W. Williams, B.J. Moore and J.W. Erdman, Jr. 1996. Lycopene sterio isomers, carotenoids, and retinol in the human prostate. Cancer, Epidemiology, Biomarkers and Prevention (submitted).

103. Panelli, M.C., T.L. Bierer, J.W. Erdman, Jr., L.M. Canfield and E.T. Akporiaye. 1996. Beta carotene does not modulate immunological functions of mouse lymphocytes in vitro. Nutr. & Cancer (submitted).

104. Lederman, J.D., B.J. Moore, K.M. Overton, N.E. Hofmann, J. Thornton and J.W. Erdman, Jr. 1996. Alterations in tissue vitamin A in ferrets following partial depletion and repletion of vitamin A. J. Nutr. (manuscript in preparation).

105. Poor, C.L., N.R. Merchen, T.L. Bierer, and J.W. Erdman, Jr. 1995. Examination of the absorption and metabolism of radiolabeled β-carotene in the preruminant calf. J. Dairy Sci. (submitted).

106. Williams, A.W., T.W.M. Boileau, S.K. Clinton and J.W. Erdman, Jr. 1996. β-carotene-enriched bovine serum – A physiologic vehicle to deliver carotenoids to prostate cancer cells in culture. J. Nutr. (manuscript in preparation).

107. Moore, A.C., E.T. Gugger and J.W. Erdman, Jr. 1996. Uptake of all-trans and 9-cis β-carotene by rat and gerbil brush border membrane vesicles. J. Nutr. (manuscript in preparation).

108. Grummer, M.A., H.H. Schmitz, S.D. Miller and J.W. Erdman, Jr. Evaluation of conversion efficiency of β-carotene to vitamin A by the rat using four dietary levels of retinyl acetate and β-carotene. J. Nutr. (manuscript in preparation).

109. Erdman, J.W., Jr., J.M. Dietz, H.C. Furr, D.B. Gunning and J.A. Olson. Effect of acute ethanol dosing on vitamin A metabolism in the rat. J. Nutr. (manuscript in preparation).

110. Liao, C.H., J.W. Erdman, Jr. and P.V. Johnston. Possible mechanisms of vitamin A deficiency on the progression of systemic lupus erythematosus (SLE) in the MRL/MPJ-Lpr/Lpl mice compared to MRL/MP +/+ mice (manuscript in preparation).

Abstracts (not published as full publication):

1. Yates, A.A. and J.W. Erdman, Jr. 1981. Effect of increasing soy isolate intake on phosphorus retention in young men. Fed. Proc. 40:942 (Abst. #4038).

2. Adams, C.E., R.A. Nelson, J.W. Erdman and R.A. Boileau. 1984. Respiratory quotients, heart rate response and lactate production during exercise in anorexia nervosa. Physiologist 27(4):255 (Abstract).

3. Smith, N.B., W.A. O'Brien, Jr. and J.W. Erdman, Jr. 1988. Ultrasonic absorption properties in excessively fatty liver. J. Accoust. Soc. Am. 83:5110 (Abst #XX12).

4. Boatright, D.J., W.D. O'Brien, Jr. and J.W. Erdman, Jr. 1988. Ultrasonic attenuation coefficient assessment in rat liver from carbon tetrachloride. J. Accoust. Soc. Am. 83:5110 (Abs #XX13).

5. Artz, W.E., J.W. Erdman, Jr., J.M. Dietz, H.H. Schmitz, R.M. Sauer, Jr. and L. Unlu. 1990. Extraction and separation of carotenoids and caratenoid cis-trans isomers from biological materials. INFORM 1(4):314 (Abstract, JAOCS).

6. Lederman, J.D., N.E. Hofmann and J.W. Erdman, Jr. 1995. The effect of prior vitamin A status on the conversion of β-carotene to vitamin A in the Mongolian gerbil. Exptl. Biol. 95. (Abstract #2656).

7. Williams, A.W., J.W. Erdman, Jr., E.T. Gugger, D.G. Bostwick and S.K. Clinton. 1995. β-carotene is found in the human prostate and can be converted to retinol by prostate cells in vitro. Exptl. Biol. 95. (Abstract #2659).

8. Merchen, N.R., T.L. Bierer and J.W. Erdman, Jr. 1995. Effect of dietary fat level in consecutive meals on the absorption of β-carotene in the preruminant calf. Exptl. Biol. 95. (Abstract #1001).

9. Bierer, T.L., N.R. Merchen and J.W. Erdman, Jr. 1995. Lack of serum uptake of 9-cis β-carotene from algal sources and a 9-cis β-carotene-enriched extract by the preruminant calf. Exptl. Biol. 95. (Abstract #2562).

10. Gugger, E.T., A.C. Moore and J.W. Erdman, Jr. 1995. Subcellular distribution of β-carotene (BC) in bovine liver. Exptl. Biol. 95. (Abstract #998).

Articles:

1. Erdman, J.W., Jr. and R.M. Forbes. 1977. Mineral bioavailability from phytate-containing foods. Food Prod. Dev. 11(10):46.

2. Weingartner, K.E. and J.W. Erdman, Jr. 1978. Human consumption of soybean foods: Mineral bioavailability considerations. Illinois Research 20(2):4-5.

3. Erdman, J.W., Jr. 1978. Bioavailability of nutrients from foods. Contemporary nutr. 3(11):1-2.

4. Erdman, J.W., Jr. 1979. Oilseed phytates: Nutritional implications. J. Am. Oil chem. 56(8):736-741.

5. Erdman, J.W., Jr. 1979. Effect of preparation and service of food on nutrient value. Food Tech. 33(2):38-48.

6. Erdman, J.W., Jr. 1979. International efforts seek to eradicate vitamin A deficiency. Food Prod. Dev. 13(4):40-42.

7. Erdman, J.W., Jr. 1979. Bioavailability of nutrients from foods. Am. Pharmacy, 19(9):42-43 and J. of Dentistry for Children, Jan-Feb, 1985.

8. Cho, B.H.S., J.W. Erdman, Jr. and J.E. Corbin. 1979. Effects of feeding raw eggs and crystalline cholesterol on cholesterol content of plasma lipoproteins in dogs in "Proceedings of the Pet Food Industry Day Symposium" Sept. 30 – Oct. 1, 1979. University of Illinois (pgs. 92-111).

9. Curan, J.M. and J.W. Erdman, Jr. 1980. How to prepare tasty meals yet retain nutrients. The Prof. Nutritionist 12(3):7-10.

10. Erdman, J.W., Jr. 1980. Bioavailability of minerals from soybean foods. Proceedings of 2nd Annual Stokely-Van Camp Symposium. "Food in the Contemporary Society. Challenges for the 80's" University of Tennessee, Knoxville, TN. Pgs. 119-132.

11. Erdman, J.W., Jr. 1980. Vitamin and mineral losses during processing and storage in "The Proceedings of the Second International Food (Pet) Symposium" Oct. 23-26, 1979, Quaker Oats, Barrington, IL pgs. 83-107.

12. Gerber, L.E. and J.W. Erdman, Jr. 1981. Retinoic acid and hypertriglyceridemia conference on modulation of cellular interactions by vitamin A and its derivatives. NY Acad. Of Sciences 359:391-392.

13. Erdman, J.W., Jr. and K.E. Weingartner. 1981. Nutritional aspects of dietary fiber in soya products. J. Am. Oil Chem. Soc. 58:511-514.

14. Erdman, J.W., Jr. and R.M. Forbes, 1981. Effects of soy protein upon mineral bioavailability. J. Am. Oil Chem Soc. 58:489-493.

15. Gerber, L.E. and J.W. Erdman, Jr. 1982. Changes in lipid metabolism during retinoid administration. J. of Am. Acad. of Dermatology 6:664-674, part 2.

16. Erdman, J.W., Jr. 1983. Factors that limit or enhance bioavailability of minerals from foods. Nutr. and the M.D. 9(2):1-2.

17. Sri Kantha, S., Erdman, J.W., Jr. 1984. Future prospects for the uses of winged bean protein sources: A review. J. Am. Oil Chem. Soc. 61:515-525.

18. Erdman, J.W., Jr. 1984. Uses of the RDA in understanding the RDA and nutrient supplements. Proceedings of the 1983 Annual Meeting of the Council for Responsible Nutrition. Phoenix, AZ. pgs. 111-119.

19. Erdman, J.W., Jr. and M.A. Grummer. 1986. Does β-carotene consumption lower cancer risk? VNIS (Backgrounder) 1:1-8, NY, NY.

20. Sri Kantha, S. and J.W. Erdman, Jr. 1986. Is winged bean really a flop? Ecol. Food Nutr. 18 (4):339-341.

21. Erdman, J.W., Jr. 1986. The adequacy of the recommended dietary allowances. In: *Food and Agricultural Research Opportunities to Improve Human Nutrition.* A.R. Doberenz, J.A. Milner and B.S. Schweigert (eds), University of Delaware, Newark, DE. Pgs. C21-C23.

22. Erdman, J.W., Jr. 1987. Health benefits of soy protein consumption for humans. 1986. Paul A. Funk Award Papers. University of Illinois, College of Agriculture Special Publication 71. pgs. 31-42.

23. Erdman, J.W., Jr., J.S. Garcia-Lopez and A.R. Sherman. 1987. Processing and fortification: How do they affect mineral interactions? In: *Nutrition 1987*. (Ed) O.A. Levander, American Institute of Nutrition, Bethesda, MD. pgs. 23-26.

24. Thompson, D.B., J.W. Erdman, Jr. and D.D. Miller. 1987. Comments on measurement of iron bioavailability in rats. Letter to the Editor. J. Nutr. 117:1645.

25. Erdman, J.W., Jr. and A.G. Poneros-Schneier. 1988. Nutrient interactions involving vitamins and minerals. Contemporary Nutr. 13(2):1-2.

26. Erdman, J.W., Jr. 1988. Nutritive value of soybean protein. In: *Soybean Utilization Alternatives*. (Ed) L. McCann, University of Minnesota Press. pgs. 169-177.

27. Erdman, J.W., Jr. 1988. The physiologic chemistry of carotenes in man Clin. Nutr. 7(3):101-106.

28. Erdman, J.W., Jr., C.L. Poor and J. Dietz. 1988. Factors affecting the bioavailability of vitamin A, β-carotene and vitamin E. Food Tech. 42(10):214-221.

29. Erdman, J.W., Jr. and E.J. Fordyce. 1989. Soy products and the human diet. Am. J. Clin. Nutr. 49:725-737.

30. Dietz, J.M. and J.W. Erdman, Jr. 1989. Effects of thermal processing upon vitamins and proteins in foods. Nutr. Today 24(4):6-15.

31. Erdman, J.W., Jr. 1989. Nutrition: The past, the present, the future. Food Tech. 43(9):220-227.

32. Erdman, J.W., Jr. 1990. Reply to letter by S.A. Witherly. Am. J. Clin. Nutr. 51:706.

33. Erdman, J.W., Jr. 1990. Protein quality of microparticulated protein. J. Am. College Nutr. 9(4):398-409.

34. Porter, D.V., R. Earl and J.W. Erdman, Jr. 1991. Nutition Labeling: Comparison of proposals for regulatory reform. Food Tech. 45(1):68-75.

35. Erdman, J.W., Jr. 1993. Update on U.S. Nutrition Standards. In: *Beyond Deficiency: Vitamin Issues of the 1990's*, pp. 64-68. Hoffmann-LaRoche, Inc., Nutley, NJ.

36. Chassy, B.M. and J.W. Erdman, Jr. 1993. Food Safety: Myth Versus Reality. Illinois Research 53(3):2-3.

37. Potter, S.M. and J.W. Erdman, Jr. Reply to L.M. Klevay, Am. J. Clin. Nutr. 60:300-1.

38. Zhou, J.R. and Erdman, J.W., Jr. 1995. Dietary phytic acid: Nutritional and biochemistry implications. Functional Foods for Health Newsletter 1(1):8-13.

39. Zhou, J.R. and Erdman, J.W., Jr. 1995. Phytic acid in health and disease. Crit. Rev. in Food Sci. & Nutr. 35:495-508.

40. Erdman, J.W., Jr. 1995. Summary: The First International Symposium on the Role of Soy in the Prevention and Treatment of Chronic Disease. J. Nutr. 125(3):798S.

41. Zhou, J.R. and J.W. Erdman, Jr. 1996. Chemical effects of processing and food preparation on carotenoids and soy and garlic phytochemicals. Am. J. Clin. Nutr. (in press).

42. Erdman, J.W., Jr. 1995. Invited Editorial. Control of serum lipids with soy protein. New England J. Med. 333:313-315.

Book Chapters:

1. Lachance, P.A. and J.W. Erdman, Jr. 1975. Effect of home practices on nutrient content of foods. In: *Nutritional Evaluation of Food Processing*, editors, R.S. Harris and E. Karmas. AVI Publ. Company, pgs. 529-567.

2. Thompson, D.B. and J.W. Erdman, Jr. 1981. Nutrient bioavailability. In: *Protein Functionality in Foods*. J.P. Cherry (Ed.) pgs. 243-274. ACS Symposium Series 147.

3. Erdman, J.W., Jr. and E.A. Erdman. 1982. Effect of home preparation practices on nutritive value of food. In: *Handbook of Nutritive Value of Processed Food Vol. 1 – Food for Human Use*. CRC Press, pgs. 237-263.

4. Erdman, J.W., Jr. and B.P. Klein. 1982. The influence of harvesting, processing, and cooking influences on vitamin C in foods. In: *Ascorbic Acid: Chemistry, Metabolism and Uses*. P.A. Seib and B.M. Tolbert (Eds), Amer. Chem. Soc., Washington, DC, pgs. 499-532.

5. Erdman, J.W., Jr., R.M. Forbes and H. Kondo. 1983. Zinc bioavailability from processed soybean products. In: *Bioavailability of Zinc*. G. Inglett (Ed), ACS Symposium Series, Washington, DC, pgs 173-183.

6. Forbes, R.M. and J.W. Erdman, Jr. 1983. Bioavailability of minerals. In*: Annual Review of Nutrition, Vol. 3.* W.J. Darby, H. Broquist, and R.E. Olson (Ed), Annual Reviewers Inc., Palo Alto, CA. Pgs. 213-231.

7. Adams, C.E. and J.W. Erdman, Jr. 1983. Food constituents and nutrition, Chapter 12. In: *Food Science and Technology Correspondence Course*. American Institute of Baking, Manhattan, KS. 45 pgs.

8. Sri Kantha, S. and J.W. Erdman, Jr. 1985. The role of fish protein concentrates (FPC) in human nutrition for the third world population: A survey of problems and future prospects. In: *11th Annual Third World Conference, Proceedings*. Third World Conference Foundation, Inc, Chicago, IL, pgs. 134-144.

9. Sri Kantha, S. and J.W. Erdman, Jr. 1986. Winged bean as a source of protein: Recent Advances. In: *Food Proteins: Applications, Biological Effects, Chemistry*. R.L. Ory (Ed). ACS Symposium Series, Washington, DC, pgs. 206-219.

10. Sri Kantha, S. and J.W. Erdman, Jr. 1987. Legume carotenoids. In: *CRC Critical Reviews in Food Technology*. CRC Press Inc., Boca Raton, FL. 26:137-155.

11. Adams, C.E., and J.W. Erdman, Jr. 1988. Effects of home food preparation practices on nutrient content of foods. In: Nutritional Evaluation of Food Processing. (Eds) E. Karmas and R.S. Harris, 3rd edition. Van Nostrand Reinhold Comp, NY, NY, pgs. 557-605.

12. Erdman, J.W., Jr. and A.G. Poneros-Schneier. 1989. Phytic acid interactions with divalent cations in foods and in the GI tract. In: Mineral Absorption in the *Monogastric GI Tract Advances in Experimental Medicine and Biology, Vol. 249*. (Eds) J.A. Laszlo and F.R. Dintzis. Plenum Publ. Corp., pgs. 161-171.

13. Erdman, J.W., Jr. 1990. Effects of soybean protein on human health. In: *Proceedings of the 14th International Congress of Nutrition*. (Eds) K.W. Young, L.C. Cha, L.K. Yoll, J.J. Soon and K.S. He. Seoul, Korea. Pgs. 755-758.

14. Mobarhan, S., J.W. Erdman, Jr. and H. Friedman. 1992. The effects of ethanol on vitamin A and β-carotene nutriture. In: *Nutrition and Alcohol*, (Eds.) R.R. Watson and B. Watzl. CRC Press, Boca Raton, FL, pgs. 269-279.

15. Schmits, H.H., C.L. Poor, E.T. Gugger and J.W. Erdman, Jr. 1993. Analysis of carotenoids in human and animal tissues. In: *Methods in Enzymology, Volume 214 Cartotoinds. Part B. Metabolism, Genersis & Biosynthesis*. (L. Packer, ed.), Chapter 11, pp. 102-116. Academic Press, Inc., San Diego, CA.

16. Erdman, J.W., Jr., T.L. Bierer and E.T. Gugger. 1993 Absorption and transport of carotenoids. In: *Carotenoids in Human Health*, (Eds.) L.M. Canfield, N.I. Krinsky and J.A. Olson, Annals of the New York Academy of Sciences, New York 691:76-85.

17. Erdman, J.W., Jr. and A.G. Poneros-Schneier. 1994. Factors affecting the nutritional value of processed foods. In: *Modern Nutrition in Health and Disease*. 8th Edition, (Eds) M.E. Shils, J.A. Olson and M. Shike. pp 1569-1578. Lea an Febiger, Philadelphia, PA.

18. Erdman, J.W., Jr. 1996. Carotenoids and Health. In: Nutrition in the 90's: Current controversies and analysis. Volume 3 (eds) F.N. Kotsonis and M.A. Mackey. Marcel Dekker, Inc., N.Y. (in press).

19. Erdman, J.W., Jr. and A. Williams. 1997. Food Processing: Nutritional and safety issues. In: Modern Nutrition in Health and Disease. 9th Edition, (eds.) M.E. Shils, J.A. Olson, M. Shike and A.C. Ross (in press).

Book Reviews:

25. Erdman. J.W., Jr. 1994. Retinoids: Progress in research and clinical applications. M.A. Livrea and L. Packer (eds.). Marcell Dekker, 1993, 649 pgs. INFORM 5:122.

CURRICULUM VITAE

Joseph F. Borzelleca

Personal History

Name:	Joseph Francis Borzelleca
Home Address:	8718 September Drive Richmond, VA 23229
S.S. No:	186-22-5009
Citizenship:	United States
Birth Date:	3 October 1930
Birth Place:	Norristown, PA
Married:	Mary E. Ford (1955); 6 children
Home Phone:	(804) 282.2004; 285.2004
Home Fax:	(804) 285.1401
Office Address:	Dept. of Pharmacology and Toxicology Medical College of Virginia Virginia Commonwealth University Box 980613 Richmond, VA 23298-0613
Office Phone:	(804) 828.8409

Educational Background

B.S.	St. Joseph's University, Philadelphia, PA Biology, Chemistry	1952
M.S.	School of Graduate Studies Thomas Jefferson University Jefferson Medical College, Philadelphia, PA Pharmacology, Physiology	1954

Ph.D.	School of Graduate Studies Thomas Jefferson University Jefferson Medical College, Philadelphia, PA. Pharmacology, Biochemistry	1956

Academic Appointments

Department of Pharmacology Medical College of Pennsylvania Philadelphia, PA	Instructor-Associate	1956-1959
Department of Pharmacology and Toxicology Medical College of Virginia Richmond, VA 23298-0613	Assistant Professor Associate Professor Professor Head, Division of Toxicology	1959-1962 1962-l967 1967- 1972-l986

Professional Certification

Fellow, Academy of Toxicological Sciences

Professional Affiliations

Societies

Academy of Toxicological Sciences**
American Association for the Advancement of Science
American Chemical Society
American College of Toxicology*

American Society of Pharmacology and Experimental Therapeutics**
(Environmental Pharmacology Committee: Liaison Committee, SOT; Toxicology Committee)

International Society for Ecotoxicology and Environmental Safety
International Society of Regulatory Toxicology and Pharmacology*
(Member of Council)

Sigma XI

Society of Experimental Biology and Medicine*
(Councillor; Program Chairman of Southeastern Section)

Society for Risk Analysis

Society of Toxicology* **
(Chairman, Awards, Education, Legislative Affairs, Membership, Nominating Committees; Secretary of the Society; Councillor; President)

Virginia Academy of Science*
(Chairman, Medical Sciences Division)

* Held elected office

** Held appointed office or position

Board of Directors

ILSI/Nutrition Foundation
American Council on Science and Health

Board of Scientific and Policy Advisors

American Council on Science and Health

Journals

Editor, Food Chemical Toxicology, 1992-

Editorial Board

Environmental Carcinogenesis Reviews, 1981-
Journal of Environmental Pathology, Toxicology and Oncology, 1977-
Journal of Environmental Science and Health, 1979-
Journal of the American College of Toxicology, 1982-
Journal of Toxicology: Cutaneous and Ocular Toxicology, 1982-1992
Journal of Applied Toxicology, 1989-
Pharmacology, 1978-
Pharmacology and Drug Development, 1980-
Toxicology and Applied Pharmacology, 1975-l 978

Reviewer

Drug Development Research
Environmental Science and Technology
Food Chemical Toxicology
Journal of Environmental Pathology and Toxicology
Journal of Environmental Science and Health
Journal of the American College of Toxicology

Journal of Toxicology: Cutaneous and Ocular Toxicology
Science
Toxicology
Toxicology and Applied Pharmacology

Consultantships (Past, Present)

Governmental

Food and Drug Administration
National Institute of Mental Health
National Cancer Institute
Environmental Protection Agency
Department of Labor - OSHA (Chairman, Carcinogens Standards Committee)
U.S. Army - Research and Development Command

Non-Governmental

National Academy of Sciences - NRC
- Committee on Toxicology (Member, Chairman)/Board on Toxicology and Environmental
- Health Hazards
- Safe Drinking Water Committee
- Evaluation of Household Substances Committee (1138 Committee)
- Food Protection Committee
- Food Additives Survey Committee

Federation of American Societies of Experimental Biology
- Select Committee on GRAS Substances
- Flavors and Extracts
- Biotechnology Product Safety
- Caprenin GRAS Committee

World Health Organization
- Joint Meeting on Pesticide Residues (JMPR) (Member, Chairman)

Industrial

Chemical Companies; Trade Associations

University Activities

Related to Instruction

Prepared a laboratory manual in pharmacology (animal and human studies) (1960)
Introduced the use of closed circuit TV and TV tapes in pharmacology (1960)
Introduced clinical pharmacological experiments into the medical and dental programs (1960)
Planning and participation in continuing education program (Schools of Dentistry, Medicine and Pharmacy)
Planning and administering each of the three major efforts in pharmacology (dental, medical, pharmacy) since 1960.
Graduate Program - assisted in developing graduate training program in toxicology

Current Teaching Activities

PMC 535- Course director
Present lectures in the following: INH 511/512; PMC 535, 536, 539; PHA 591; MPH 604; PIO (MPH V) 691; PMC 400, 404; PMC 609; Dietetic Intern Program; M-l;

Honors Biology; Nutrition electives

Not Directly Related to Instruction

Elected senator from the graduate school, then vice-president of the University Senate

Served on various committees (e.g. Curriculum, Search, Animal Care,) in each of the four major schools (Dentistry, Graduate, Medical, Pharmacy)

Research

Research has been continuously funded since 1956. Sources of support include governmental (U.S.P.H.S.; N.I.H; E.P.A.; N.I.D.A.) and non-governmental (industrial). (A list of publications is attached).

Awards

DOD - US Army - Chemical Research Development and Engineering Center Distinguished Service Award, 1986

National Italian - American Foundation Award
Excellence in Medicine and Community Service, 1987

Thomas Jefferson University
Distinguished Alumnus Award, 1987

Virginia Commonwealth University -School of Basic Health Sciences
Outstanding Faculty Award, 1987

Virginia Commonwealth University - School of Basic Health Sciences, Dept. of Pharmacology and Toxicology
Professor of the Year- 1992

PUBLICATIONS

Borzelleca, J.F. and Manthei, R.W.: Factors influencing pentobarbital sleeping time in mice. Arch. Int. Pharmacodyn. *111*: 296, 1957.

Borzelleca, J.F.: Studies of the contribution of bladder absorption to the physiological changes induced by pentobarbital. J. Pharm. Exp. Ther. *129*: 305, 1960.

Borzelleca, J.F.: The absorption of nicotine from the urinary bladder of the dog. Arch. Int. Pharmacodyn. *133*: 444, 1961.

Borzelleca, J.F., Bowman, E.R. and McKennis, H., Jr.: The cardiovascular and respiratory effects of (-)-cotinine. J. Pharmacol. Exp. Ther. *137*: 313, 1962.

Borzelleca, J.F.: Drug absorption from the urinary tract of the rat. Nicotine. Arch. lnt. Pharmacodyn. *143*: 595, 1963.

Borzelleca, J.F.: Influence of saline and glucose infusions on the course of barbiturate intoxication. Arch. Int. Pharmacodyn. *146*: 163, 1963.

Larson, P.S., Borzelleca, J.F., Bowman, E.R., Crawford, E.M., Smith, R.B., Jr. and Henningar, G.R.: Toxicologic studies on a preparation of p-tertiary octylphenoxy-polyethoxy ethanols (Trition X-405). Toxicol. Appl. Pharmacol. *5*: 782, 1963.

Borzelleca, J.F., Larson, P.S., Henningar, G.R., Hug, E.G., Crawford, E.M. and Smith, R.B., Jr.: Studies on the chronic oral toxicity of monomeric ethyl acrylate and methyl methacrylate. Toxicol. Appl. Pharmacol. *6*: 29, 1964.

Borzelleca, J.F. and Cherrick, H.: The excretion of drugs in saliva. Antibiotics. J. Oral Therap. Pharmacol. *2*: 180, 1965.

Borzelleca, J.F. and Lester, D.: Acute toxicity of some perhalogenated acetones. Toxicol. Appl. Pharmacol. *7*: 592, 1965.

Borzelleca, J.F.: Drug movement from the isolated urinary bladder of the rabbit. Arch. Int. Pharmacodyn. *154:*40, 1965.

Borzelleca, J.F.: Rabbit urinary bladder potentials. Invest. Urol. *3*: 77, 1965.

Borzelleca, J.F.: Studies on the mechanisms of drug movement from the isolated urinary bladder. J. Pharmacol. Exp. Ther. *148*: 111, 1965.

Lowenthal, W. and Borzelleca, J.F.: Drug absorption from the rectum. I. J. Pharm. Sci. *54*: 1790, 1965.

Ambrose, A.M., Borzelleca, J.F., Larson, P.S., Smith, R.B., Jr. and Hennigar, G.R.: Toxicologic studies on monochloroacetaldehyde: 2,4-dinitrophenylhydrazone, a foliar fungicide. Toxicol. Appl. Pharmacol. *8*: 472, 1966.

Borzelleca, J.F. and Doyle, C.H.: Excretion of drugs in saliva. Salicylate, barbiturate, sulfanilamide. J. Oral. Therap. Pharmacol. *3*: 104, 1966.

Borzelleca, J.F. and Lowenthal, W.: Drug absorption from the rectum. II. J. Pharm. Sci. *55*: 151, 1966.

Wooles, W.R. and Borzelleca, J.F.: Prolongation of barbiturate sleeping time in mice by stimulation of the reticuloendothelial system. J. Reticuloendo. Soc. *3*: 41, 1966.

Wooles, W.R., Borzelleca, J.F. and Branham, G.W.: The effects of acute and prolonged salicylate administration on liver and plasma triglyceride levels and dietary-induced hypercholesterolemia. Toxicol. Appl. Pharmacol. *10*: 1, 1967.

Borzelleca, J.F., Harris, T. and Bernstein, S.: The effect of DMSO on drug movement through the wall of the urinary bladder of the rabbit. J. Invest. Urol. *6*: 43, 1968.

Borzelleca, J.F.: The excretion of glucose in saliva. Dog. J. Oral Therap. Pharmacol. *4*: 338, 1968.

Kim, K.S., Borzelleca, J.F., McKennis, H. and Bowman, E.R.: Pharmacological effects of some nicotine metabolites and related compounds. J. Pharmacol. Exp. Ther. *161*: 59, 1968.

Marcus, S. and Borzelleca, J.F.: Observations of reserpine-induced bradycardia. Arch. Int. Pharamacodyn. *174*: 12, 1968.

Schwartz, S.L. and Borzelleca, J.F.: Adrenergic blood pressure response in the shark. Science *163*: 395, 1969.

Ambrose, A.M., Borzelleca, J.F., Larson, P.S. and Hennigar, G.R.: The toxicology of a foliar fungicide, GC-4072. Toxicol. Appl. Pharmacol. *17*: 323, 1970.

Borzelleca, J.F. and Putney, J.W., Jr.: A model for the movement of salicylate across the parotid epithelium. J. Pharmacol. Exp. Ther. *174*: 527, 1970.

Borzelleca, J.F. and Putney, J.W., Jr.: Studies on the biotransformation of salicylic acid by the salivary gland. Arch. Int. Pharmacodyn. *188*: 127, 1970.

Lowenthal, W., Borzelleca, J.F. and Corder, C.D., Jr.: Drug absorption from the rectum. III. Aspirin and some aspirin derivatives. J. Pharm. Sci. *59*: 1353, 1970.

Putney, J.W., Jr. and Borzelleca, J.F.: A method for the determination of small quantities of salicylate metabolites in the presence of a great excess of salicylic acid. Arch. Int. Pharmacodyn. *188*: 119, 1970.

Wynn, J.E., van't Riet, B. and Borzelleca, J.F.: Excretion and toxicity of EGTA and EDTA after oral administration to rats. Toxicol. Appl. Pharmacol. *16*: 807, 1970.

Ambrose, A.M., Larson, P.S., Borzelleca, J.F., Smith, R.B., Jr. and Hennigar, G.R.: Toxicologic studies on 2,4-dichlorophenyl-p-nitrophenyl ether. Toxicol. Appl. Pharmacol. *19*: 263, 1971.

Borzelleca, J.F., Larson, P.S., Crawford, E.M., Hennigar, G.R., Jr., Kuchar, E.J. and Klein, H.H.: Toxicologic and metabolism studies on pentachloronitrobenzene. Toxicol. Appl. Pharmacol. *18*:522, 1971.

Putney, J.W., Jr. and Borzelleca, J.F.: On the mechanisms of ^{14}C- salicylic acid distribution in rat submaxillary gland in vitro. J. Pharmacol. Exp. Ther. *117*: 263, 1971.

Putney, J.W., Jr. and Borzelleca, J.F.: On the mechanisms of ^{14}C-nicotine distribution in rat submaxillary gland in vitro. J. Pharmacol. Exp. Ther. *178*: 180, 1971.

Ambrose, A.M., Larson, P.S., Borzelleca, J.F. and Hennigar, G.R.: Toxicologic studies on 3',4'-dichloropropionanilide. Toxicol. Appl. Pharmacol. *23*: 650, 1972.

Egle, J.L., Jr., Putney, J.W., Jr. and Borzelleca, J.F.: Cardiac rate and rhythm in mice affected by haloalkane propellants. J.A.M.A. *222*: 786, 1972.

Putney, J.W., Jr. and Borzelleca, J.F.: On the mechanisms of ^{14}C-salicylic acid excretion by the rat submaxillary gland. J. Phamacol. Exp. Ther. *182*: 515, 1972.

Putney, J.W., Jr. and Borzelleca, J.F.: Active accumulation of ^{14}C -salicylic acid by rat kidney cortex *in vitro*. J. Pharmacol. Exp. Ther. *186*: 600, 1973.

Borzelleca, J.F.: Safety evaluation and toxicological tests and procedures. J.A.O.A.C. *58*: 692, 1975.

Adams, M.D., Wedig, J.H., Jordan, R.L., Smith, L.W., Henderson, R. and Borzelleca, J.F.: Urinary excretion and metabolism of salts of 2-pyridinethiol-1-oxide following intravenous administration to female Yorkshire pigs. Toxicol. Appl. Pharmacol. *36*: 523, 1976.

Allen, M.A., Wrenn, J.M., Putney, J.W., Jr. and Borzelleca, J.F.: A study of the mechanism of transport of diphenylhydantoin in the rat submaxillary gland *in vitro*. J. Pharmacol. Exp. Ther. *197*: 408, 1976.

Ambrose, A.M., Larson, P.S., Borzelleca, J.F. and Hennigar, G.R.: Long-term toxicologic assessment of nickel in rats and dogs. J. Food Science and Technology *13*: 181, 1976.

Egle, J.L., Jr., Long, J.E., Simon, G.S. and Borzelleca, J.F.: An evaluation of the cardiac sensitizing potential of a fabric protector in aerosol form, containing 1 ,l ,l-trichloroethane. Toxicol. Appl. Pharmacol. *38*: 369, 1976.

Egle, J.L., Jr., Fernandez, S.B., Guzelian, P.S. and Borzelleca, J.F.: Distribution and excretion of chlordecone (Kepone) in the rat. Drug Metab. Dispos. *6*:91, 1976

Munson, A.E., Barrett, B.A. and Borzelleca, J.F.: *In vitro* experimental approaches to detection of sensitive agents. In: Cutaneous Toxicity. (V. Drill, ed.), Academic Press, Inc., San Francisco, p. 175, 1977.

Weinberg, A.D., Dimen, E.M., Borzelleca, J.F. and Harris, L.S.: Weight and activity in male mice after daily inhalation of cannabis smoke in an automated smoke exposure chamber. J. Pharm. & Pharmac. *29:* 477, 1977.

Weinberg, A. D., Dimen, E.M., Simon, G.S., Harris, L.S. and Borzelleca, J.F.: Measurements of weight and activity in male mice following inhalation of cannabis smoke in a controlled smoke exposure chamber. Toxicol. Appl. Pharmcol. *42*: 301, 1977.

Allen, M.A. Wrenn, J.M., Putney, J.W., Jr. and Borzelleca, J.F.: A study of the mechanisms of transport of benzylpenicillin in the rat submaxillary gland. Arch. Int. Pharmacodyn. *233:* 180, 1978.

Bowman, F.J., Borzelleca, J.F. and Munson, A.E.: The toxicity of some halomethanes in mice. Toxicol. Appl. Pharmacol. *44*: 213, 1978.

Egle, J.L., Fernandez, S.B., Guzelian, P.S. and Borzelleca, J.F.: Distribution and excretion of chlordecone (Kepone) in the rat. Drug Metab. Dispos. *6*: 91, 1978.

McConnell, W.R. and Borzelleca, J.F.: A study of the mechanism of transport of Δ9-tetrahydrocannabinol in the rat submaxillary gland *in vivo*. Arch. Int. Pharmacodyn *235*: 180, 1978.

McConnell, W.R., Dewey, W.L., Harris, L.S. and Borzelleca, J.F.: A study of the effect of delta-9-tetrahydrocannabinol (delta-9-THC) on mammalian salivary flow. J. Pharmacol. Exp. Ther. *206*: 567. 1978.

Schumann, A.M. and Borzelleca. J.F.: An assessment of the methemoglobin and Heinz body inducing capacity of pentachloronitrobenzene in the cat. Toxicol. Appl. Pharmacol. *44*: 523, 1978.

Simon, G.S., Tardiff, R.G. and Borzelleca, J.F.: Potential mutagenic and adverse male reproductive effects of 1,2,3,4-tetrabromobutane. A dominant lethal study in the rat. Toxicol. Appl. Pharmacol. *44*: 661, 1978.

Carmines, E.L., Carchman, R.A. and Borzelleca, J.F.: Kepone: Cellular sites of action. Toxicol. Appl. Pharmacol. *49*: 543, 1979.

Egle, J.L., Jr., Guzelian, P.S. and Borzelleca, J.F.: Time course of the acute toxic effects of sublethal doses of chlordecone (Kepone). Toxicol,. Appl. Pharmacol. *48*: 553, 1979.

Larson, P.S., Egle, J.L., Jr., Hennigar, G.R.. and Borzelleca, J.F.: Acute and subchronic toxicity of mirex in the rat, dog, and rabbit. Toxicol. Appl. Pharmacol. *49*: 271, 1979.

Shopp, G.M., White, K.L., Jr., Holsapple, M.P., Barnes, D.W., Duke, S.S., Anderson, A.C., Condie, L.W., Jr., Hayes, JR. and Borzelleca, J.F.: Naphthalene toxicity in CD-1 mice: general oxicology and immunotoxicology. Fund. Appl. Toxicol. *4*: 406, 1984.

Borzelleca, J.F. and Hogan, G.K.: Chronic toxicity/carcinogencity study of FD&C Blue No. 2 in mice. Food Chem. Tox. *23*: 719, 1985.

Borzelleca, J.F., Hayes, JR., Condie, L.W. and Egle, J.L., Jr.: Acute toxicity of monochlorophenols, dichlorophenols and pentachlorophenol in the mouse. Toxicol. Letters 29: *39*, 1985.

Borzelleca, J.F., Hayes, JR., Condie, L.W. and Egle, J.L.: Acute and subchronic toxicity of 2,4-dichlorophenol in CD-1 mice. Fund. Appl. Toxicol. *5*: 478, 1985.

Borzelleca, J.F., Hogan, G.K. and Koestner A.: Chronic toxicity/carcinogencity study of FD&C Blue No. 2 in rats. Food Chem. Tox. *23*: 551, 1985.

Hayes, J.R. and Borzelleca, J.F.: Nutrient interaction with drugs and other xenobiotics, J. Am. Dietetic Assoc. *85*: 3 335, 1985.

Lane, R.W., Simon, Glen, S.S., Dougherty, R.W., Egle, J.L. and Borzelleca, J.F.: Reproductive toxicity and lack of dominant lethal effects of 2,4-dinitrotolune in the male rat. Drug and Chem. Tox. *4*: 265, 1985.

Borzelleca, J.F., Goldenthal, E.I. and Wazeter, F.X.: A multigeneration study of FD&C Blue No. 2 in rats. Food Chem. Tox. *24*: 159, 1986.

Charles, J.L., Jacobson-Kram, D., Condie, L.W., Jr., Borzelleca, J.F. and Carchman, R. A.: The kinetics of *in vitro* sister chromatid exchange induction in mouse bone marrow cells by ethylnitrosourea and methylnitosourea. Toxicol. Appl. Pharmacol. *84*: 56, 1986.

Hayes, J.R., Condie, L.W., Jr. and Borzelleca J.F.: The subchronic toxicity of tetrachorethylene (perchloroethylene) administered in the drinking water of rats. Fund. Appl. Toxicol. *7*: 119, 1986.

Hayes, J.R., Condie, L.W., Jr. and Borzelleca, J.F.: Acute, 14-day repeated dosing and 90-day subchronic toxicity studies of carbon tetrachloride in CD-1 mice. Fund. Appl. Toxicol. *7*: 454, 1986.

Hayes, J.R., Condie, L.W., Jr. and Borzelleca, J.F.: Acute, 14-day repeated dosing, and 90-day subchronic toxicity studies of potassium picloram. Fund. Appl. Toxicol. *7*: 464, 1986.

Hayes, J.R., Condie, L.W., Jr. and Borzelleca, J.F.: Toxicology of haloacetonitriles. Environ. Health Perspec. *69*: 183, 1986.

Lane, R.W., Sturm, R.J., Borzelleca, J.F. and Carchman, R.A.: Effect of *in vitro* differentiation on phorbol diester receptor number in human promyelocytic leukemia (HL-60) cells. Cancer Res. *46*: 3782, 1986.

Simon, G.S., Egle, J.L., Jr., Dougherty, R.W. and Borzelleca, J.F.: Dominant lethal assay of chlordecone and its distribution in the male reproductive tissues of the rat. Tox. Letters *30*: 237, 1986.

Tarka, S.M., Jr., Applebaum, R.S. and Borzelleca, J.F.: Evaluation of the prenatal, postnatal and teratogenic effects of coca powder and theobromine in Sprague-Dawley/CD rats. Food Chem. Tox. *24*: 375, 1986.

Tarka, S.M., Jr., Applebaum, R.S. and Borzelleca, J.F.: Evaluation of the teratogenic potential of cocoa powder and the bromine in New Zealand white rabbits. Food Chem. Tox. *24*: 363, 1986.

Borzelleca, J.F., Capen, C.C. and Hallagan, J.B.: Lifetime toxicity/carcinogenicity study of FD&C Red no. 3 (erythrosine) in rats. Fd. Chem. Toxic. *25*: 723, 1987.

Borzelleca, J.F., Capen, C.C., and Hallagan, J.B.: Lifetime toxicity/carcinogenicity study of FD&C Red No. 3 (erythrosine) in mice. Fd. Chem. Toxic. *25*: 735, 1987.

Hayes, J.R., Condie, L.W., Jr., Egle, J.L., Jr. and Borzelleca, J.F.: The acute and subchronic toxicity in rats of trans-1,2 dichloroethylene in drinking water. J.Am. Coll. Toxicol. *6*: 471, 1987.

Borzelleca, J.F. and Hallagan, J.B.: Chronic toxicity/carcinogenicity studies of FD&C Yellow No. 5 (tartrazine) in rats. Fd. Chem. Toxic. *26:* 179, 1988.

Borzelleca, J.F., Condie, L.W., Jr. and Egle, J.L.: Short-term toxicity (one-and ten-day gavage) of barium chloride in male and female rats. J. Am. Coll. Toxicol. *7*: 675-685, 1988.

Condie, L.W., Jr., Hill, J.R. and Borzelleca, J.F.: Oral toxicology studies with xylene isomers and mixed xylenes. Drug and Chem. Tox. *11*: 329, 1988.

Borzelleca, J.F. and Hallagan, J.B.: A chronic toxicity/carcinogenicity study of FD&C yellow no. 5 (tartrazine) in mice. Fd. Chem. Toxic. *26*: 189, 1988.

Borzelleca, J.F., Clark, E.C. and Condie, L.W., Jr.: Short-term toxicity (1 and 10 days) of cadmium chloride in male and female rats: gavage and drinking water. J. Am. Coll. Toxicol. *8*: 377, 1989.

Borzelleca, J.F., Condie, L.W., Jr., Clarke, E.C. and Egle, J.L.: Short-term toxicity (one and ten day gavage) of potassium dichromate in male and female rats. J. Am. Coll. Toxicol. *8*: 1197, 1989.

Borzelleca, J.F., Olson, J.W.A. and Reno, F.A.: Lifetime toxicity/carcinogenicity study of FD&C red No. 40 (allura red) in Sprague-dawley rats. Fd. Chem. Tox. *27*: 701, 1989.

Borzelleca, J.F.: Status of colors and flavors used in the confectionery industry. Proc. 106th Annual Convention of the National Confectioners Association of the United States. 33, 1989.

Lamb, R.G., Borzelleca, J.F., Condie, L.W. and Gennings, C.: Toxic interactions between carbon tetrachloride and chloroform in cultured rat hepatocytes. Toxicol. Appl. Pharmacol. *101*: 106, 1989.

O'Hara, T.M., Borzelleca, J.F., Clark, E.C., Sheppard, M.A. and Condie, L.W., Jr.: A $CCl_4/CHCl_3$ interaction study in isolated hepatocytes: selection of a vehicle. Fund. Appl. Toxicol. *13*: 605, 1989.

Borzelleca, J.F. and Hallagan, J.B.: Multigeneration study of FD&C red no. 3 (erythrosine) in Sprague-dawley rats. Fd. Chem. Tox. 28: 813, 1990

Borzelleca, J.F., Depukat, K. and Hallagan, J.B.: Lifetime toxicity/carcinogenicity studies of FD&C blue no. 1 (brilliant blue FCF) in rats and mice. Fd. Chem. Toxic. 28: 221, 199O.

Borzelleca, J.F., O'Hara, T.M., Gennings, C., Granger, R.H., Sheppard, M.A. and Condie, L.W., Jr.: Interactions of water contaminants. I. Plasma enzyme activity and response surface methodology following gavage administration of $CC1_4$ and $CHC1_3$ or TCE singly and in combination in the rat. Fund. Appl. Toxicol. *14*: 477, 1990.

Borzelleca, J.F., Olson, J.W.A. and Reno, F.A.: Lifetime toxicity/carcinogenicity study of FD&C red no. 40 (allura red) in mice. Fd. Chem. Tox. *29*: 313, 1991.

O'Hara, T.M., Sheppard, M.A., Clarke, E.C., Borzellecam J.F., Gennings, C. and Condie, L.W., Jr.: A $CCl_4/CHCl_3$ interaction study in isolated hepatocytes: non-induced, and phenobarbital pretreated cells. J. Appl. Toxicol. 11: 147, 1991

Borzelleca, J.F.: Assessment of Safety/Risk of Chemicals- Inception and Evolution of the ADI and Dose-Response Modeling Procedures- Commentary. Tox. Letters 59:1, 1991

Borzelleca, J.F.: The safety evaluation of macronutrient substitutes. CRC Critical Reviews in Food Science and Nutrition. 32:127, 1992

Borzelleca, J.F.: Macronutrient Substitutes: Safety Evaluation. Reg. Tox. Pharm. 16: 253, 1992

Waddell, W.J., Borzelleca, J.F., Doull, J., Grasso, P., LeBourhis, B., Levy, P.S. and Tamburro, C.H. Alcohol and Cancer. Br. J. Cancer. 66:1200, 1992

Borzelleca, J.F: Evaluation of the safety of tara gum as a food ingredient: a review of the literature. J. Am. Coil. Tox. 12 (1): 81,1993

Borzelleca, J.F. and Egle, J. L. Jr.: An evaluation of the reproductive and developmental effects of tara gum in rats. J. Am. Coll. Tox. 12 (1): 91, 1993

Borzelleca, J.F.: Interactions of environmental chemicals and toxins in Proceedings of the Second Princess Chulabhorn Science Congress:" Environment, Science and Technology: the Challenges of the 21st Century." 1993

Borzelleca, J.F., Egle, J.L., Jr., Harris, L.S., Johnson, D.N., Terrill, J.B. and Belleville, J.A.N.: Toxicological Evaluation of u-Agonists Part I. Assessment of Toxicity Following 30 Days of Repeated Oral Dosing of Male and Female Rats with Levo-Alpha-Acetylmethadol HCI (LAAM). J. Appl. Tox. 14 (6): 435, 1994

Conn, R.E., Kolstad, J.J., Borzelleca, J.F., Dixler, D.S., Filer, L.J., Jr., LaDu, B.N., Jr, and Pariza, M.W.: Safety Assessment of Polylactide (PLA) for Use as a Food-contact Polymer. Fd. Chem. Tox. 33: 273, 1995

Hallagan, J.B., Allen, D.C., and Borzelleca, J.F.: The safety and regulatory status of food, drug and cosmetics color additives exempt from certification. Fd. Chem. Toxic. 33:515, 1995

Borzelleca, J.F.: Post-Marketing Surveillance of Macronutrient Substitutes. Fd. Tech. 49:107-113, 1995

Borzelleca, J.F., Egle, J.L., Jr., Harris, L.S. and Belleville, J.A.N.: Toxicological Evaluation of u-Agonists. Part II: Assessment of toxicity Following 30 Days of Repeated Oral Dosing of Male and Female Rats with Leno-alpha-noracetylmethadol HCI (NorLAAM). J. Appl. Tox. 15(5): 339-355, 1995

Moore, K.A., Lichtman, A.H., Poklis, A., and Borzelleca, J.F.: alpha-Benzyl-N-methylphenethylamine (BNMPA), an impurity of illicit methamphetamine synthesis: pharmacological evaluation and interaction with methamphetamine. Drug and Alcohol Dependence 39:83-89, 1995

Borzelleca, J.F., Filer, L.J., Jr., Kinoshita, F.K., Gerrish, T.C., Kuo, P.K., and LaDu, B.N.: Evaluation of the safety of sodium pectate as a good ingredient. Fd. Chem. Toxic. 34:21, 1996

ABSTRACTS

Borzelleca, J.F. and Manthei, R.W.: Influence of dehydration on pentobarbital sleeping time in mice. Fed. Proc. *15*: 403, 1956.

Borzelleca, J.F.: The effect of blood pH on barbiturate sleeping time in mice. Fed. Proc. *16*: 284, 1957.

Borzelleca, J.F.: Drug absorption from the urinary bladder. Fed. Proc. *18:* 370, 1959.

Borzelleca, J.F.: Nicotine absorption from the urinary bladder of the dog. Fed. Proc. *19*.: 391, 1960.

Borzelleca, J.F., Bowman, E.R. and McKennis, H., Jr.: Depressor effects arising from (-)-cotinine. Pharmacologist *2:* 72, 1960.

Borzelleca, J.F.: Influence of saline infusions on the course of barbiturate intoxication. Pharmacologist *3*: 63, 1961.

Borzelleca, J.F.: Drug absorption from the urinary tract of the rat. Nicotine. Fed. Proc. *21*: 451, 1962.

Borzelleca, J.F.: Drug movement from the isolated urinary bladder of the rabbit. Fed. Proc. *22*: 661, 1963.

Borzelleca, J.F.: Studies on the mechanisms of drug movement from the isolated urinary bladder. Pharmacologist *6*: 178, 1964.

Kim, K.S., Borzelleca, J.F., McKennis, H., Jr. and Bowman, E.R.: Effects of cotinine and other nicotine metabolites *in vitro* on duodenum and ileum segments. Fed. Proc. *23*: 330, 1964.

Borzelleca, J.F. and Doyle, H.: Salivary excretion of drugs. Fed. Proc. *24*: 546, 1965.

Cherrick, H. and Borzelleca, J.F.: Salivary excretion of drugs. Antibiotics. Toxicol. Appl. Pharmacol. *7*: 481, 1965.

Wooles, W.R. and Borzelleca, J.F.: Prolongation of barbiturate sleeping time in mice by stimulation of the RES. J.R.E.S, *1*: 574, 1965.

Borzelleca, J.F.: Salivary excretion of glucose, salicylate, penicillin. Fed. Proc. *24*: 564, 1966.

Lowenthal, W. and Borzelleca, J.F.: Rectal absorption of salicylates. Toxicol. Appl. Pharmacol. *8*: 347, 1966.

Bernstein, S. and Borzelleca, J.F.: The effect of dimethylsulfoxide on drug transfer from the urinary bladder. Va. J. Sci. *18*: 195, 1967.

Kim, K.S. and Borzelleca, J.F.: Pharmacological effects of some nicotine metabolites and related compounds. Fed. Proc. *26*: 683, 1967.

Mullen, K. and Borzelleca, J.F.: Predictive model for blood glucose concentration in the dog. Va. J. Sci. *18:* 200, 1967.

Schwartz, S.L. and Borzelleca, J.F.: Adrenergic blood pressure responses in the shark. Proc. Shark Res. Panel of Am. Inst. Biol. Sci., 26 April 1968.

Schwartz, S.L. and Borzelleca, J.F.: Adrenergic responses in the shark. Toxicol. Appl. Pharmacol. *12*: 307, 1968.

Wynn, J.E., van't Riet, B. and Borzelleca, J.F.: Excretion and toxicity of EGTA and EDTA after oral administration to rats. Fed. Proc. *271*: 465, 1968.

van't Riet, B., O'Rear, C.E., Wynn, J.E. and Borzelleca, J.F.: Effect of EGTA and EDTA on bladder stone formation in rats. Toxicol. Appl. Pharmacol. *14*: 638, 1969.

Borzelleca, J.F. and van't Riet, B.: Hydrolysis and excretion of esters of EDTA and EGTA after oral administration to rats. Va. J. Sci. *29*: 143, 1970.

Borzelleca, J.F., Larson, P.S., Hennigar, G.R. and Kuchar, E.J.: A toxicological evaluation of pentachloronitrobenaene (PCNB). Pharmacologist *12*: 208, 1970.

Borzelleca, J.F.: The role of pharmacology in the training of toxicologists. Pharmacologist *12*: 217, 1970.

Putney, J.W., Jr. and Borzelleca, J.F.: A model for drug movement across the salivary epithelium. Va. J. Sci. *21*: 147, 1970.

Putney, J.W., Jr. and Borzelleca, J.F.: Factors modifying excretion of salicylate by the dog, comparison of urinary and salivary routes. J. Toxicol. Appl. Pharmacol. *16*: 23, 1970.

Putney, J.W., Jr. and Borzelleca, J.F.: Studies on salicylate biotransformation by the salivary gland. Pharmacologist *12*: 272, 1970.

Borzelleca, J.F., Larson, P.S., Hennigar, G.R. and Kuchar, E.J.: A toxicologic valuation of 5-ethoxy-3-trichloromethyl- 1,2,4-thiadiazole (terrazole). Toxicol. Appl. Pharmacol. *19*: 79, 1971.

Putney, J.W., Jr. and Borzelleca, J.F.: Mechanisms of ^{14}C-salicylate uptake by submaxillary gland slices. Fed. Proc. *30*: 448, 1971.

Putney, J.W., Jr. and Borzelleca, J.F.: Active uptake of ^{14}C-salicylic acid by rat kidney cortex slices. Fed. Proc. *31*: 518, 1972.

Putney, J.W., Jr. and Borzelleca, J.F.: Participation of extracellular hydrogen ion in the efflux of nicotine-^{14}C from submaxillary gland cells. Pharmacologist *13*: 518, 1972.

Allen, M.A. and Borzelleca, J.F.: On the method of benzyl penicillin-^{14}C potassium distribution in rat submaxillary gland. Fed. Proc. *32*: 733, 1973.

Allen, M.A. and Borzelleca, J.F.: On the method of diphenyl hydantoin distribution in rat submaxillary gland. Pharmacologist *15*: 229, 1973.

Jordan, R.L. and Borzelleca, J.F.: Teratogenic studies with pentachloronitrobenzene in rats. Toxicol. Appl. Pharmacol. *25*: 454, 1973.

Allen, M.A. and Borzelleca, J.F.: Diphenylhydantoin distribution in rat submaxillary gland: influence of age. Fed. Proc. *33*: 525, 1974.

Burnett, C.M., Agersborg, H.P.H., Jr., Borzelleca, J.F., Egle, Jr., E., Ebert, A.G., Pierce, E.C., Kirschman, J.C. and Scala, R.A.: Teratogenic studies with certified colors in rats and rabbits. Toxicol. Appl. Pharmacol. *29*: 121, 1974.

Pierce, E.G., Agersborg, H.P.K., Jr., Borzelleca, J.F., Burnett, C.M., Egle, E., Ebert, A.G., Kirschman, J.C. and Scala, R.A.: Multigeneration reproduction studies with certified colors in rats. Toxicol. Appl. Pharmacol. *29*: 121, 1974.

Adams, M., Wedig, J.H., Jordan, R., Smith, L., Henderson, R. and Borzelleca, J.F.: Excretion and metabolism of three 2-6-^{14}C Omadines following intravenous injection in female Yorkshire pigs. Toxicol. Appl. Pharmacol. *33*: 180, 1975.

Egle, J.L., Jr., Borzelleca, J.F. and Long, J.E.: An evaluation of the cardiac sensitizing potential of Scotchgard brand fabric protector. Toxicol. Appl. Pharmacol. *33*: 154, 1975.

Jordan, R.L. and Borzelleca, J.F.: Teratogenic studies with zinc Omadine in swine. Anat. Rec. *18*: 388, 1975.

McConnell, W.R., Borzelleca, J.F. and Chambers, J.W.: The effects of delta-g-tetrahydrocannabinol (THC) on electrically stimulated saliva from cat submaxillary gland. Fed. Proc. *34*: 782, 1975.

Smith, L.W., Borzelleca, J.F. and Bowman, E.R.: Application of isolated cell suspensions to the study of membrane phenomena in mammalian salivary cells. Fed. Proc. *34*: 752, 1975.

Wrenn, J.M. and Borzelleca, J.F.: Effect of phenobarbital and pentobarbital on the transport of diphenylhydantoin in salivary tissues and saliva. Fed. Proc. *34*: 573, 1975.

Egle, J.L., Jr., Gochberg, B.J. and Borzelleca, J.F.: The distribution of ^{14}C-Kepone in the rat. Pharmacologist *18*: 195, 1976.

McConnell, W.R. and Borzelleca, J.F.: On the method of 3H-delta-9 tetrahydrocannabinol (3H-delta-9-THC) distribution in the submaxillary gland of the rat. Pharmacologist *18*: 149, 1976.

McConnell, W.R., Borzelleca, J.F. and Dewey, W.L.: The mechanism by which delta-g-tetrahydrocannabinol (THC) produces a decrease in salivary flow following electrical stimulation. Fed. Proc. *35*: 644, 1976.

McCoy, W.D., Kuchar, E.J., Klein, H.H. and Borzelleca, J.F.: Biotransformation and distribution of pentachloronitrobenzene in chickens. Toxicol. Appl. Pharmacol. *37*: 175, 1976.

Schumann, A.M. and Borzelleca, J.F.: The potential methomoglobin and Heinz body inducing capacity of pentachloronitrobenzene (PCNB) in the cat. Toxicol. Appl. Pharmacol. *37*: 171, 1976.

Schumann, A.M., Bloom, A.S., Dewey, W.L., Harris, L.S. and Borzelleca, J.F.: Development of central catecholamine systems in the postnatal rat brain. The Pharmacologist *18*: 243, 1976.

Smith, L.W. and Borzelleca, J.F.: Uptake of cadmium in rat submaxillary slices. The Pharmacologist *18:* 196, 1976.

Bagshaw, B., Schumann, A., Borzelleca, J. and Dewey, W.: The effects of chloroform and bromoform on the noradrenergic and dopaminergic systems of the mouse brain. Pharmacologist *9*: 200, 1977.

Barrett, B.A., Sanders, V.M., Borzelleca, J.F., Munson, E.: Growth rates and tumor takes in mice with transplanted tumors exposed to halomethanes. Va. J. Sci. *28:* 100, 1977.

Brady, K.T., Sanders, V.M. Borzelleca, J.F. and Munson, A.E.: The acute toxicity of the halomethanes: drinking water contaminants. Va. J. Sci. *28*: 100, 1977.

Martin, B.R., Dewey, W.L., Beckner, J.S. and Borzelleca, J.F.: Synthesis and metabolism of brain serotonin in mice following acute exposure to several haloalkanes. Toxicol. Appl. Pharmacol. *19*: 200, 1977.

Munson, A., Sanders, V., Borzelleca, J. and Barnes, D.: Toxicologic studies on adult and neonatal mice exposed to the trichloromethanes: drinking water contaminants. Pharmacologist *19*: 200, 1977.

Munson, A.E., Sanders, V.M., Barrett, B.A. and Borzelleca, J.F.: Functional activity of the reticuloendothelial system in mice exposed to haloalkanes for ninety days. J. Reticuloendo. Soc. *22*: 17a, 1977.

Sanders, V.M., Barrett, B.A., Borzelleca, J.F. and Munson, A.E.: Reticuloendothelial system activity and cell mediated immune responsiveness in mice exposed to polychlorinated biphenyls. J. Reticuloendo. Soc. *22*: 16a, 1977.

Schumann, A.M., Dewey, W.L. and Borzelleca, J.F.: The effects of triethyllead on central catecholamine function in the adult rat. Toxicol. Appl. Pharmacol. *41*: 208, 1977.

Schumann, A.M., Dewey, W.L., Borzelleca, J.F. and Alphin, R.S.: The effects of lead acetate on central catecholamine function in the postnatal mouse Fed. Proc. *36*: 405, 1977.

Smith, L.W. and Borzelleca, J.F.: The excretion of cadmium and mercury in saliva. Toxicol. Appl. Pharmacol. *41*: 153, 1977.

Smith, L.W., Ismay, J.A. and Borzelleca, J.F.: Movement of mercury in rat submaxillary slices. Fed. Proc. *36*: 355, 1977.

Carmines, E.L., Burkhalter, J.A., Carchman, R.A. and Borzelleca, J.F.: Inhibitory effects of chloroform on P388D macrophage cell. Fed. Proc. *37*: 320, 1978.

Dougherty, R.W., Simon, G.S., Campbell, K.I. and Borzelleca, J.F.: Failure of 2,4-dinitrotoluene to induce dominant lethal mutations in the rat. Pharmacologist *20*: 155, 1978.

Larson, P.S., Hennigar, G.R., Lane, R.W. and Borzelleca, J.F.: Acute, subchronic and chronic toxicological studies with kepone. Toxicol. Appl. Pharmacol. *95*: 331, 1978.

Munson, A.E., Sanders, V.M., Borzelleca, J.F., Tardiff, R.G. and Barrett, B.A.: Reticuloendothelial system function in mice exposed to four haloalkane drinking water contaminants. Toxicol. Appl. Pharmacol. *45*: 329, 1978.

Schuller, G.B., Kauffmann, B.M., Borzelleca, J.F., Sanders, V.M. and Munson, A.E.: Effect of four haloalkanes on humoral and cell mediated immunity in mice. Toxicol. Appl. Pharmacol. *45*: 329, 1978.

Simon, G.S., Carchman, R.A. and Borzelleca, J.F.: Diabetes: responses to selected pharmacologic agents. Pharmacologist *20*: 151, 1978.

Simon, G.S., Kipps, B.R., Tardiff, R.G. and Borzelleca, J.F.: Failure of Kepone and hexachlorobenzene to induce dominant lethal mutations in the rat. Toxicol. Appl. Pharmacol. *45*: 330: 1978.

Smith, S.H., Sanders, V.M., Barrett, B.A., Borzelleca, J.F. and Munson, A.E.: lmmunotoxicological evaluation on mice exposed to polychlorinated biphenyls. Toxicol. Appl. Pharmacol. *45*: 330, 1978.

Zimmerman, M.L., Lane, R.W., Skalsky, H.L. and Borzelleca, J.F.: Excretion of carbaryl into saliva and its effect on cholinesterase. 10th Inter-American Conf. on Toxicol. and Occupational Med., p. 47, 1978.

Zimmerman, M.L., May, R.G. and Borzelleca, J.F.: Excretion of carbaryl into the saliva of the rat. Toxicol. Appl. Pharmacol. *45*: 35, 1978.

Balster, R.L., Burkhalter, J. and Borzelleca, J.F.: Behavioral toxicity evaluation of four halomethane contaminants of drinking water in adult mice. Fed. Proc. *38*: 846, 1979.

Carmines, E.L., Carchman, R.A. and Borzelleca, J.F.: In vitro effects of Kepone. Va. J. Sci. *30*: 89, 1979.

Borzelleca, J.F., Skalsky, H.L. and Riddle, B.L.: Effects of dibromochloromethane in drinking water on reproduction and development in mice. Fed. Proc. *39*: 999, 1980.

Carmines, E.L., Carchman, R.A. and Borzelleca, J.F.: Analysis of the interactions between paraquat and DNA. Fed. Proc. *39*: 545, 1980.

Balster, R.L., Kallman, M.J. and Borzelleca, J.F.: Behavioral toxicity evaluation of trihalomethane contaminants of drinking water. Health Effects of Drinking Water Symposiun, 1981.

Carchman, R.A., Cardlin, E.L., Skalsky, H.L. and Borzelleca, J.F.: The effects .of selected water disinfectant products on testicular DNA metabolism. Health Effects of Drinking Water Symposium, 1981.

Kallman, M.J., Balster, R.L., Kaempf, G.L. and Borzelleca, J.F.: Behavioral toxicity evaluation of chloral in adult mice. Fed. Proc. *40*: 698, 1981.

Tarka, S.M., Jr., Keeney, P.G., and Borzelleca, J.F.: The effect of pretreatment with dietary cocoa on growth and reproductive performance in young and adult rats. Fed. Proc. *40*: 668, 1981.

Lane, R.W., Carchman, R.A. and Borzelleca, J.F.: Characterization of DNA metabolism in mouse primary spermatocytes. Toxicologist *1*: 39(#143), 1981.

Riddle, B.L., Carchman, R.A. and Borzelleca, J.F.: Effects of 1,2-dichloroethane and 1, l, l-trichloroethane in drinking water on reproduction and development in mice. Toxicologist *1*: 26 (#95), 1981.

Tarka, S.M., Jr., Keeney, P.G. and Borzelleca, J.F.: A comparison of the effects of methylxanthine-containing food stuffs on reproductive capacity in rats. Toxicologist *1*: 147 (#533), 1981.

Borzelleca, J.F., Hallagan, J., Reese, C., Goldenthal, E. and Hogan, G.: Chronic oral toxicity/carcinogenicity studies of food, drug and cosmetic colors in CD-1 mice J. Am. Coll. Tox. *2*: 240 (#108), 1982.

Charles, J.L., Carchman, R.A., Kram, D. and Borzelleca, J.F.: Time course of *in vivo* induction of sister chromatid exchange by ethylnitrosourea and methylnitrosourea. Toxicologist *2*: 175 (#613), 1982.

Hayes, J.R., Condie, L.W., Jr., and Borzelleca, J.F.: Kinetics of naphthalene (NTL) covalent binding to hepatic DNA, RNA and protein in CD-1 mice. J. Am. Coll. Tox. *8*: 144, 1982.

Lane, R.W., Coles, R.B., Carchman, R.A. and Borzelleca, J.F.: Phorbol diester receptors on HL-60 human promyelocytic leukemia cells. Toxicologist *2*: 105 (#373), 1982

Seyler, D., East, J. and Borzelleca, J.F.: Cadmium depression of mouse *in vitro* fertilization. Toxicologist *2*: 238 (#764), 1982.

Borzelleca, J.F., Hallagan, J., Reese, C., Goldenthal, E. and Hogan, G.: Chronic oral toxicity/carcinogenicity studies of food, drug and cosmetic colors in CD rats. Toxicologist 3: 129 (#514), 1983.

Condie, L.W., Hayes, JR. and Borzelleca, J.F.: Acute and subchronic oral toxicity of 2,4-dichlorophenol (2,4-DCP) in male and female CD-1 mice. Pharmacologist *25*: 228, 1983.

Hayes, J.R. and Borzelleca, J.F. Implications of nutrient-drug interactions. Proc. Ann. Meeting Inst. Fd. Technol., 1983.

Hayes, J.R. and Borzelleca, J.F.: Diet-nutrient interactions. Proc. Ann. Mtg. of the Am. Diet. Assoc., 1983.

Hayes, J.R., Condie, L.W., Jr., and Borzelleca, J.F.: Pharmacokinetics of oral naphthalene (NTL) in CD-1 mice. Toxicologist *3*: 161 (#844), 1983.

Kallman, M.J., Borzelleca, J.F. and Condie, L., Jr.: Behavioral toxicity of naphthalene in adult mice. J. Am. Coll. Tox. *2*: 247 (#136), 1983.

Kessler, F.K., Charles, J.L., Borzelleca, J.F. and Carchman, R.A.: Effects o of chlorinated phenols on mouse bone marrow sister chromatid exchange. J. Am. Coll. Tox. *2*: 249 (#142), 1983.

Lane, R.W., Carchman, R.A. and Borzelleca, J.F.: Phorbol diester (PDE) binding and oxygen metabolism of differentiated HL-60 cells. Toxicologist 3: 144 (#575), 1983.

Shopp, G.M., White, K.L., Jr., Holsapple, M.P., Barnes, D.W., Condie, L.W., Jr. and Borzelleca, J.F.: General toxicology and immunotoxicology of mice exposed to naphthalene (NAP). Toxicologist, *3*: 57 (#226), 1983.

Smith, B., Lane, R.W., Carchman, R.A. and Borzelleca, J.F.: A comparison of the reversibility of phorbol diester induced changes in macrophage morphology. Toxicologist *3*: 144 (#574), 1983.

Borzelleca, J.F., Hayes, J,R. and Condie, L.: Toxicological evaluation of selected chlorinated phenols and haloacetonitriles. Proc. of 5th International Conf. on Water Chlorination: Environmental Impact and Health Effects *1*: 100, 1984.

Hayes, J.R., Condie, L. and Borzelleca, J.F.: Subchronic toxicity of carbon tetrachloride administered by oral gavage to CD-1 mice. Toxicologist *4*: 183 (#730), 1984.

Hayes, J.R., Condie, L.W. and Borzelleca, J.F.: Acute and 14-day continuous dosing toxicity of dichloroacetonitrile (DCA) and dibromoacetonitrile (DBA). Pharmacologist *26:* 233, 1984.

Condie, L.W. Hayes, J.R. and Borzelleca, J.F.: Acute, 14-day and subchronic toxicity of potassium picloram (PIC) administered to rats via the drinking water. Toxicologist *5:* 222, 1985

Capen, C.C., Nishikawa, S., Ingbar, S.H., Braverman, L.E., and Borzelleca J.F.: Mechanisms of thyroid oncogenesis by chronic erythosine (red. no. 3) feeding: ultrastructural and morphometic evaluation of thyroid glands and changes in circulating levels of thyroid hormones and thyrotropin (TSH). Abstract No. 48, 75th Annual Meeting of the International Academy of Pathology, New Orleans, 10-14 March, and publised in Laboratory Investigations *54:* 54 a, 1986.

Lamb, R.G., Bush, S.R., Condie, L.W., and Borzelleca, J.F.: Influence of chlorinated hydrocarbon mixtures on cultured hepatocyte function. Pharmacologist *28:* 180, 1996.

Lamb, R.G., Coleman, J.B. Condie, L.W., and Borzelleca, J.F.: Influence of chlorinated hydrocarbons on cultured hepatocyte function. Toxicologist *6*: 116 (#470), 1986.

Granger, R.H. Coleman, J.B., Condie, L.W., Lamb R.G. and Borzelleca, J.F.: Effect of vehicle on the relative uptake of haloalkanes administered by gavage. Toxicologist *7*: 265 (# 1060) 1987.

Lamb, R.G., Coleman, J.B., Granger, H., Condie, L.W. and Borzelleca, J.F.: The influence of chlorinated hydrocarbons on hepatocyte function *in vivo* and *in vitro*. Toxicologist *7*: 267 (#1068), 1987.

Coleman, J.B., Condie, L.W., Borzelleca, J.F. and Lamb, R.G.: The influence of structural analogues of carbon tetrachloride (CCI_4) on hepatocyte functions *in vitro*. Toxicologist *8*: 96 (#381), 1988.

Cranger, R.H., O'Hara, T.M., Condie, L.W., and Borzelleca, J.F.: A study of the joint action of carbon tetrachloride (CCI_4) and trichloroethylene (C_2HCI_3) following simultaneous gavage administration in the rat. Toxicologist *8*: 95 (#378), 1988.

O'Hara, T.M., Granger, R.H., Condie, L.W. and Borzelleca, J.F.: A study of the joint hepatotoxic action on carbon terachloride (CCI_4) and chloroform ($CHCI_3$) following simultaneous gavage administration in the rat. Toxicologist *8*: 96 (#380), 1988.

Borzelleca, J.F., O'Hara, T.M., Gennings, C. and Condie, L.W., A CCI_4-$CHCI_3$ interaction study in isolated hepatocytes-the role of P-450 metabolism. Toxicologist *9*: 58 (#229), 1989.

Lamb, R.G., Gennings, C., Borzelleca, J.F., and Condie, L.W.: Toxic interactions between carbon tetrachloride (CCl_4) and chloroform ($CHCl_3$). Toxicologist *9*: 59 (#233), 1989.

O'Hara , T.M., Borzelleca, J.F. and Condie, L.W.: A CCl_4/$CHCl_3$ interaction study in isolated hepatocytes-selection of a vehicle. Toxicologist *9*: 59 (#235), 1989.

Borzelleca, J.F., Gennings, C., Bercz, P. and Lamb, R.G. :Toxic interactions between carbon tetrachloride ($CC1_4$) and perchloroethylene (PCE) in cultured rat hepatocytes. Toxicologist *10*:54 (#213), 1990.

Lamb, R.G., Gennings, C., Borzelleca, J.F. and Bercz, P.: Toxic interactions between carbon tetrachloride (CCI_4) and trichloroethylene (TCE) in cultured rat hepatocytes. Toxicologist *10*: 53 (#212), 1990.

Wolfe, G., Myers, B., Lemen, J., Lauer, W., Johns, F., Condie, L. and Borzelleca, J.: Preliminary report of the findings of the health effects for Denver's potable reuse demonstration project .Toxicologist *10*: 176 (#704), 1990.

Egle, J.L., Jr., Borzelleca, J.F. and Harris, L.S.: Acute and subchronic toxicity of Levo-alpha-acetyl-methadol (LAAM) and Levo-alpha-acetyl-normethadol (NORLAAM) in male and female rats. Toxicologist *11*: 149 (#521), 1991.

Weiner, M.L., Steinberg, M., Borzelleca, J.F., Enters, E.K., Hager, D.F., Konoshita, F.K., Loper, A., Mitchell, D.B. and Tamulinas, C.B.: Proposed safety evaluation guidelines for new excipients. Toxicologist 13: 213 (#796), 1994.

Borzelleca, J.F.: The safety evaluation of macronutrient substitutes. IFT Annual Meeting Abstracts #15-2, 1994.

Borzelleca, J.F.: Fat replacers. ACS meeting,

BOOKS and BOOK CHAPTERS

Skalsky, H.L., Lane, R.W. and Borzelleca, J.F.: "Excretion of carbaryl into saliva of the rat and its effect on cholinesterase". In: Toxicology and Occupational Medicine (W.B. Deichman, ed.), p. 349, 1979.

Borzelleca, J.F. and Carmines, E.L.: "New drug evaluation: safety assessment". In: Program for Applied Research on Fertility Regulation, 1980.

Hayes, J.F. and Borzelleca, J.F.: "Biodisposition of environmental chemicals by animals". In: Animal Products in Human Nutrition (D. Beitz and R. Hansen, eds.), Chap. 11, p. 225. Academic Press, New York, 1982.

Borzelleca, J.F.: "Neurobehavior toxicological testing". Pharmacodependence and neurobehavioral toxicology. Quo Vadis ?, Symposium "Quo Vadis ?", Sanofi Group, Montpellier, France, p. 115, 1983.

Schwartz, S.L. and Borzelleca, J.F.: "Toxicology of polyvinylpyrrolidone". Proceedings of the International Symposium on Povidone (G.A. Digenis, Ed.), College of Pharmacy, University of Kentucky, Lexington, KY, p. 234, 1983.

Borzelleca, J.F., Hallagan, J. and Reese, C.: "Food, Drug and Cosmetic Colors: Toxicological Considerations." ACS Symposium Series, No. 234, Xenobiotics in Foods and Feeds. (Finley, J.W. and Schwass, D.E., eds.), Chap. 20, p.311. ACS, Washington, D.C., 1983.

Borzelleca, J.F.: "Extrapolation of animal data to man". In: Toxicology Laboratory Design and Management for the 80's and Beyond (Tegeris, A.S., Ed.); Vol. 1 of Concepts in Toxicology, Homburger, F., Series Ed.), 1984.

Borzelleca, J.F.: "Current concepts in reproductive toxicology". In: Clinics in Laboratory Medicine, Symposium on Environmental and Occupational Health Hazards, Vol. 4 (R.V. Blanke, ed.), W.B. Saunders Co., Philadelphia, 1984.

Borzelleca, J.F., Condie, L.W., and Hayes, JR.: "Toxicological evaluation of selected chlorinated phenols". In Water Chlorination, Chemistry, Environmental Impact and Health Effects. (R.L. Jolley, R.J. Bull, W.P. Davis, S. Katz, M.H. Roberts, Jr., V.A. Jacobs). Volume, 5, Chap. 28, p.331, 1985.

Robinson, B.V., Sullivan, F.M., Borzelleca, J.F. and Schwartz, S.L.: PVP: A Critical Review of the Kinetics and Toxicology of Polyvinylpyrrolidone (Povidone). Lewis Publishers, Inc., Michigan, 1990.

Borzelleca, J.F. and Hallagan, J.B.: "Safety and Regulatory Status of Food, Drug, and Cosmetic Colors." ACS Symposium Series, No. 484, Food Safety Assessment. (Finley, J.W., Robinson, S.F., and Armstrong, D.J., eds.), Chap. 31, p.377, 1992.

Borzelleca, J.F.: "Foods of the Future: What Will We Be Eating in the Next Century?" In Practical Handbook of Nutrition in Clinical Practice (Kirby, D.F. and Dudrick , S.J., eds.), Chap. 18, p.279, 1994. CRC Press, Inc., Boca Raton, FI. 1994.

Borzelleca, J.F.: "History of Toxicology." In Principles and Methods of Toxicology (Hayes, A.W., editor), edition 3, chapter 1, p.1, 1994.

Matt, D.W. and Borzelleca, J.F.: "Toxic Effects on the Female Reproductive System During Pregnancy, Parturition, and Lactation". In Reproductive Toxicology (Witorsch, R.J., editor), edition 2, chapter 10, p. 175, 1995.

Contributing authorship on the following publications of the Life Sciences Research Office,

Federation of American Societies of Experimental Biology (FASEB)

Research Office, Federation of American Societies of Experimental Biology (FASEB):

Evaluation of the health aspects of iron and iron salts as food ingredients. 1973.

Evaluation of the health aspects of butylated hydroxytoluene as a food ingredient. 1973.

Evaluation of the health aspects of certain zinc salts as food ingredients. 1973.

Evaluation of the health aspect of pulps as they may migrate to food from packaging materials. 1973.

Evaluation of the health aspects of propylene glycol and propylene glycol monostearate as food ingredients. 1973.

Evaluation of the health aspects of alginates as food ingredients. 1973.

Evaluation of the health aspects of agar-agar as a food ingredient. 1973.

Evaluation of the health aspects of certain red and brown algae as food ingredients. 1973.

Evaluation of the health aspects of cellulose and certain cellulose derivatives of food ingredients. 1973.

Iodine in foods: chemical methodology and sources of iodine in the human diet. 1974.

Evaluation of the health aspects of aconitic acid as a food ingredient. 1974.

Evaluation of the health aspects of stannous chloride as a food ingredient. 1974.

Evaluation of the health aspects of licorice, glycyrrhiza and ammoniated glycrrhizin as food ingredients. 1974.

Evaluation of the health aspects of caprylic acid as a food ingredient. 1974.

Evaluation of the health aspects of sorbose as a food ingredient. 1974.

Evaluation of the health aspects of sulfuric acid and sulfates as food ingredients. 1974.

Evaluation of the health aspects of potassium iodide, potassium iodate, and calcium iodate as food ingredients. 1975.

Evaluation of the health aspects of dextran as food ingredients. 1975.

Evaluation of the health aspects of calcium oxide and calcium hydroxide as food ingredients. 1975.

Evaluation of the health aspects of succinic acid as a food ingredient. 1975.

Evaluation of the health aspects of certain calcium salts as food ingredients. 1975.

Evaluation of the health aspects of glycerin and glycerides as food ingredients. 1975.

Evaluation of the health aspects of dextrin and corn dextrin as food ingredients. 1975.

Evaluation of the health aspects of sodium thiosulfate as a food ingredient. 1975.

Evaluation of the health aspects of gelatin as a food ingredient. 1975.

Evaluation of the health aspects of bile salts and ox bile extract as food ingredients. 1975.

Evaluation of the health aspects of choline chloride and choline bitartrate as food ingredients. 1975.

Evaluation of the health aspects of aluminum compounds as food ingredients. 1975.

Evaluation of the health aspects of tallow, hydrogenated tallow, stearic acid, and calcium stearate as food ingredients. 1975.

Evaluation of the health aspects of phosphates as food ingredients. 1975.

Evaluation of the health aspects of the tocopherols and a-tocopheryl acetate as food ingredients. 1975.

Evaluation of the health aspects of sorbic acid and its salts as food ingredients. 1975.

Evaluation of the health aspects of hydrogenated fish oil as a food ingredient. 1975.

Evaluation of the health aspects of beeswax (yellow or white) as a food ingredient. 1975.

Evaluation of the health aspects of inositol as a food ingredient. 1975.

Evaluation of the health aspects of malic acid as a food ingredient. 1975.

Evaluation of the health aspects of Japan Wax as a substance migrating to food from cotton or cotton fabrics used in dry food packaging. 1976.

Evaluation of the health aspects of carnauba wax as a food ingredient. 1976.

Evaluation of the health aspects of sulfamic acid as it may migrate to foods from packaging materials. 1976.

Evaluation of the health aspects of hydrosulfites as they may migrate to foods from packaging materials. 1976.

Evaluation of the health aspects of gum guaiac as a food ingredient. 1976.

Evaluation of the health aspects of tall oil as it may migrate to foods from packaging materials. 1976.

Evaluation of the health aspects of corn sugar (dextrose), corn syrup and invert sugar as food ingredients. 1976.

Evaluation of the health aspects of sucrose as a food ingredient. 1976.

Evaluation of the health aspects of sulfiting agents as food ingredients. 1976.

Evaluation of the health aspects of glycerophosphates as food ingredients. 1976.

Evaluation of the health aspects of magnesium salts as food ingredients. 1976.

Evaluation of the health aspects of sodium hydroxide and potassium hydroxide as food ingredients. 1976.

Evaluation of the health aspects of adipic acid as a food ingredient. 1976.

Evaluation of the health aspects of hydrogenated soybean oil as a food ingredient. 1996.

Evaluation of the health aspects of formic acid, sodium formate, and ethyl formate as food ingredients. 1976.

Evaluation of the health aspects of lard and lard oil as they may migrate to foods from packaging materials. 1976.

Evaluation of the health aspects of pyridoxine and pyridoxine hydrochloride as food ingredients. 1977.

Evaluation of the health aspects of papain as a food ingredient. 1977.

Evaluation of the health aspects of hypophosphites as food ingredients. 1977.

Evaluation of the health aspects of coconut oil, peanut oil, and oleic acid as they migrate to food from packaging materials, and linoleic acid as a food ingredient. 1977.

Evaluation of the health aspects of pectin and pectinates as food ingredients. 1977.

Evaluation of the health aspects of tannic acid as a food ingredient. 1977.

Evaluation of the health aspects of rennet as a food ingredient. 1977.

Evaluation of the health aspects of acetic acid and sodium acetate as food ingredients. 1977.

Evaluation of the health aspects of sodium oleate and sodium palmitate as substances migrating to food from paper and paperboard used in food packaging. 1977.

Evaluation of the health aspects of corn silk as a food ingredient. 1977.

Evaluation of the health aspects of bentonite and clay (kaolin) as food ingredients. 1977

Evaluation of the health aspects of citric acid, sodium citrate, potassium citrate, calcium citrate, ammonium citrate, triethyl citrate, isopropyl citrate, and stearyl citrate as food ingredients. 1977.

Evaluation of the health aspects of lactic acid and calcium lactate as food ingredients. 1978.

Evaluation of the health aspects of calcium pantothenate, sodium pantothenate, and D-pantothenyl alcohol as food ingredients. 1978.

Evaluation of the health aspects of Vitamin B12 as a food ingredient. 1978.

Evaluation of the health aspects of Vitamin D2 and Vitamin D3 as food ingredients. 1978.

Evaluation of the health aspects of caffeine as a food ingredient. 1978.

Evaluation of the health aspects of certain glutamates as food ingredients. 1978.

Evaluation of the health aspects of protein hydrolyzates as food ingredients. 1978.

Evaluation of the health aspects of butylated hydroxyanisole as a food ingredient. 1978.

Evaluation of the health aspects of sodium, potassium, magnesium and zinc gluconates as food ingredients. 1978.

Evaluation of the health aspects of urea as a food ingredient. 1978.

Evaluation of the health aspects of thiamin hydrochloride and thiamin mononitrate as food ingredients. 1978.

Evaluation of the health aspects of biotin as a food ingredient. 1978.

Evaluation of the health aspects of ascorbic acid, sodium ascorbate, calcium ascorbate, erythorbic acid, sodium erythorbate, and ascorbyl palmitate as food ingredients. 1979.

Evaluation of the health aspects of propionic acid, calcium propionate, sodium propionate, dilauryl thiodipropionate, and thiodipropionic acid as food ingredients. 1979.

Evaluation of the health aspects of casein, sodium caseinate, and calcium caseinate as food ingredients. 1979.

Evaluation of the health aspects of nickel as a food ingredient. 1979

Evaluation of the health aspects of soy protein isolates as food ingredients. 1979.

Evaluation of the health aspects of carotene (B-carotene) as a food ingredient. 1979.

Evaluation of the health aspects of nitrogen, helium, propane, n-butane, isobutane, and nitrous oxide as gases used in foods. 1979.

Evaluation of the health aspects of hydrogen peroxide as a food ingredient. 1979.

Evaluation of the health aspects of riboflavin and riboflavin-5-l-phosphate as food ingredients. 1979.

Evaluation of the health aspects of starch and modified starches as food ingredients. 1979.

Evaluation of the health aspects of carbon dioxide as a food ingredient. 1979.

Evaluation of the health aspects of sodium chloride and potassium chloride as food ingredients. 1979.

Evaluation of the health aspects of certain silicates as food ingredients. 1979.

Evaluation of the health aspects of manganous salts as food ingredients. 1979.

Evaluation of the health aspects of copper gluconate, copper sulfate, and cuprous iodide as food ingredients. 1979.

Evaluation of the health aspects of hydrochloric acid as a food ingredient. 1979.

Evaluation of the health aspects of lecithin as a food ingredient. 1979.

Evaluation of the health aspects of potassium acid tartrate, sodium potassium tartrate, sodium tartrate and tartaric acid as food ingredients. 1979.

Evaluation of the health aspects of starter distillate and diacetyl as food ingredients. 1980.

Vitamin A, Vitamin A Acetate, and Vitamin A Palmitate as food ingredients. 1980.

Evaluation of the health aspects of iron and iron salts as food ingredients. 1980.

Evaluation of the health aspects of protein hydrolyzates as food ingredients. 1980.

Evaluation of the health aspects of collagen as a food ingredient. 1981.

Evaluation of the health aspects of methyl polysilicones as food ingredients. 1981.

Evaluation of the health aspects of soya fatty acid amines as food ingredients. 1981.

Evaluation of the health aspects of activated carbon (charcoal) as a food processing aid. 1981.

Evaluation of the health aspects of smoke flavoring solutions and smoked yeast flavoring as food ingredients. 1981.

Evaluation of the health aspects of commint oil as a food ingredient. 1981.

Evaluation of the health aspects of a mixture. Evaluation of the health aspects of diferous, dipotassium ferrous, and potassium ferrocyanides as finding agents in wine production. 1981.

Evaluation of the health aspects of wheat gluten, corn gluten, and zein as food ingredients. 1981.

Evaluation of the health aspects of peptones as food ingredients. 1981.

Evaluation of the health aspects of shellac and shellac wax as food ingredients. 1981.

Evaluation of the health aspects of sodium metasilicate and sodium zinc metasilicate as food ingredients. 1981.

Evaluation of the health aspects of oat gum, okra gum, quince seed gum, and psyllium seed husk gum as food ingredients. 1982.

Contributing Authorship on the Following Publications of the National Academy of Sciences

Principles and Procedures for Evaluating the Toxicity of Household Substances.
Committee for the Revision of NAS Publication 1138, Committee on Toxicology,
Assembly of Life Sciences, National Research Council, National Academy of Sciences
National Academy Press, Washington, D.C. 1977

Drinking Water and Health.
Safe Drinking Water Committee, Board on Toxicology and Environmental Health Hazards,
Assembly of Life Sciences, National Research Council, National Academy of Sciences

Volume 1, 1977; Volume 2, 1980, Volume 3, 1980
National Academy Press, Washington, D.C.

Estimating Consumer Exposure to Food Additives and Monitoring Trends in Use.
Food Additives Survey Committee, Food and Nutrition Board, Institute of Medicine, National Academy of Sciences
National Academy Press, Washington, D.C. 1992