

# WHEN SAFE ISN'T GOOD ENOUGH

The record for the poultry industry regarding food safety has been good. However, the public demands the impossible task of zero tolerance. Where does the industry go from here? ■ by *Charlie Olentine*

*“Should You Eat Irradiated Meat?” (USA Weekend, January 23, 1998)...*

*“Meat Plants Continue Operations Despite Multiple Health Violations” (Birmingham News, January 18, 1998)...*

*“Chicken: What You Don’t Know CAN Hurt You” (Consumer Reports, March 1998)...*

Pick up any newspaper or listen to the television magazine shows and, in more cases than not, the issue of food safety will be discussed. Today’s communication technology provides almost instantaneous broadcasts of news worldwide; so much so, that an *E. coli* or food poisoning incident in Massachusetts or Oregon will be on the national news that same evening. “Food Safety” is a phrase that will continue to challenge the poultry industry for years to come. Fortunately, technology is being developed to help the poultry processor deal with the challenges of controlling foodborne pathogens.

The HACCP (hazard analysis critical control point) concept changes the

**Table 1.** Evaluation of *E. coli* Test Results<sup>1</sup>

Types of poultry	Lower limit of marginal range	Upper limit of marginal range	Number of samples tested	Maximum number permitted in marginal range
Chickens	100 CFU/ml	1,000 CFU/ml	13	3
Turkeys <sup>2</sup>	NA	NA	NA	NA

<sup>1</sup> FSIS Directive 5000.1, Attachment 1. Three tube Most Probable Number (MPN) method.  
<sup>2</sup> Not available; values for turkeys will be added upon a completion of data collection program for turkeys.

**Table 2.** Salmonella Performance Standards<sup>1</sup>

Class of Product	Performance Standard (Percent Positive for Salmonella)	Number of Samples Tested	Maximum Number of Positives to Achieve Standard
Broilers	20.0	51	12
Ground Chicken	44.6	53	26
Ground Turkey	49.9	53	59
Turkey <sup>2</sup>	NA	NA	NA

<sup>1</sup> FSIS Directive 5000.1, Attachment 1. Three tube Most Probable Number (MPN) method.  
<sup>2</sup> Not available; values for turkeys will be added upon a completion of data collection program for turkeys.

rules on how we inspect poultry; and while the transition to the new system will be bumpy, it offers potential for enhancing food safety by stressing controlling contamination through microbial monitoring as opposed to the old system that focused solely upon visual inspection. Tables 1 and 2 illus-

trate the tolerance levels for *E. coli* and salmonella, respectively (FSIS Directive 5000.1, Attachment 1).

## Scope of the Problem

The Centers for Disease Control estimates that between six million and 80 million people are hit with foodborne illnesses in the U.S. every year. The impact is enormous with a financial impact of \$5 billion and a cost of life of 9,000. In the investigation of foodborne illnesses, several organisms have direct links to poultry; and from a broader perspective, the challenges to the entire meat and poultry industries are intertwined. Table 3 illustrates the im-

**Table 3.** Estimated Number of Illnesses and Deaths in the U.S. Caused by Selected Foodborne Organisms.

Pathogen	Estimated cases	Estimated deaths	Implicated foods
<i>Campylobacter jejuni</i>	4,000,000	200-1,000	Poultry, raw meat, untreated water
Salmonella (nontyphoid)	2,000,000	500-2,000	Eggs, poultry, meat, produce
<i>E. coli</i> O157:H7	25,000	100-200	Ground beef, raw milk, lettuce, unpasteurized apple juice/cider untreated water
<i>Listeria monocytogenes</i>	1,500	250-500	Ready-to-eat foods

Altekruse, et al.

## ANTIMICROBIAL INTERVENTION

pact of several organisms that are frequently associated with meat and poultry products.

### The Targets

Foodborne pathogens are extremely pervasive in the environment with several being commonly associated with meat and poultry products. In 1998, the newly mandated HACCP program provides a new approach to meat and poultry inspection, one key component of which is microbiological monitoring of the processing line. The new system has been superimposed over the older visual appraisal system prompting outcry by the industry of additional cost for implementation. However, the poultry industry is, in general, favorably supportive of the HACCP concept, recognizing that the ultimate goal is to minimize the potential for problems.

Table 4 (shown on pages 28-29) provides a summary of the major organisms of concern relating to foodborne illness associated with meat and poultry.

### Controlling Contamination: Mechanical Perspectives

One of the most significant developments in controlling microbial contamination has come from the development of eviscerating equipment that physically separates the viscera from the carcass early in the process. The viscera travels in parallel with the carcass through the line, allowing inspection with a minimum of chance for cross-contamination. This technology has also allowed processors to increase line speeds dramatically.

A variety of manufacturers are offering this type of technology (see BROILER INDUSTRY, April 1997), and the technology is working. Recent research from the University of Georgia (Russell and Walker, 1997) demonstrated that the new technology (Stork Nu-Tech system) produces products with fewer coliforms and performs better in visual inspection than did the traditional evisceration techniques. While the research was limited to the evaluation of the Nu-Tech system, the concept of separating the viscera from the carcass, such as with other systems (*i.e.*, Maestro from Meyn and Sani-Vis

from Johnson) appears to be a good initial step in controlling contamination on the processing line.

European processors have traditionally used air chilling instead of the cold water chilling techniques used in the U.S. and claim to provide cleaner carcasses due to the fact that the carcasses are not exposed to contaminated water. However, through the use of chlorine in chiller water, microbial contamination has traditionally been kept in check with the additional benefit of improving the shelf life of the product over air chilling techniques.

### Controlling Contamination: Chemical Agents

Processing of birds can never totally prevent microbial exposure. Thus, the use of chemical agents to kill and/or retard the growth of pathogens is essential. A wide variety of products has been tested with specific advantages and disadvantages to each. Auburn researchers (Tamblyn, *et al.*, 1997) compared a number of compounds using a skin attachment model to determine the antibacterial efficacy of potential carcass treatments. Table 5 summarizes the results.

Speaking at the National Meeting on Poultry Health & Processing (1997), Amy Waldroup, a researcher at the University of Arkansas, outlined a number of factors to consider when using antimicrobial products. Among them are the following:

- Approval from the government (FDA, USDA and EPA all play roles in clearance of antimicrobials)
- Labeling
- Safety to workers
- Product alterations (Does the compound affect the taste or color of the final product?)
- Corrosion to equipment
- Antimicrobial efficacy in the processing environment

### Chlorine Compounds

Dr. Waldroup stated at the meeting that chlorine is the most commonly used chemical disinfectant in poultry plants. Citing the National Broiler Council's recommendation for chlorine to be used on all equipment surfaces (20 ppm) and in the immersion chiller (20 to 50 ppm), she outlined the

various forms of chlorine that can be used. Chlorine gas, sodium hypochlorite and on-site generated chlorine are now being used. Calcium hypochlorite is another form of chlorine (see page 41) that reportedly has been used recently by some poultry processors including Sanderson Farms and ConAgra Poultry.

The University of Arkansas researcher points out that in order to control pathogens on the postchill carcass, levels of 0.5 to 1.0 ppm available chlorine must be maintained at the end of the chiller. From a mode of action point of view, chlorine treatments' effectiveness is highly dependent on pH. At pH levels of 6.0 to 6.5 chlorine treatments exhibit high degrees of bactericidal activity. Once pH goes over 7.0, the effectiveness drops off rapidly. She pointed out that most processors do not monitor pH of the chill water and would probably be very surprised to see that, in many cases, pH could exceed 7.6.

While chlorine is an effective treatment, excessive levels can produce off-flavor and carcass discoloration. Additionally, chlorine compounds can be corrosive to equipment and can pose skin irritation and other health problems for workers.

Chlorine dioxide (ClO<sub>2</sub>) has been approved by FDA as a secondary direct food additive permitted in food for human consumption and is allowed as an antimicrobial agent in process water at a level of 3 ppm residual ClO<sub>2</sub>. It has been shown to be four to seven times more effective than chlorine in killing salmonella, having 2.6 times the oxidizing power of chlorine. Advantages include a wider range of pH for effectiveness, extremely low generation of mutagenic compounds and less corrosion to equipment because of lower concentrations. ClO<sub>2</sub> can be as effective as 20 ppm chlorine, but it becomes difficult to sustain the necessary levels in the chiller to be effective and can be more expensive. Traditional uses of ClO<sub>2</sub> in the processing plant have been limited because of the need for multi-stepped generation of ClO<sub>2</sub> which can yield variable and hard to maintain levels of the product. It also involves several hazardous chemical components. Several manufacturers are developing stabilized ClO<sub>2</sub> products, therein eliminating the need for expensive genera-

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**Table 5.** Effect (log 10 reduction colony-forming units per skin) Against Freely Suspended *S. Typhimurium*.

Compound	Application		
	Chiller (0C/60 minutes)	Dip (23C/15s)	Scalder (50C/2 minutes)
20 ppm Sodium hypochlorite	>6.7	5.1	>6.7
400 ppm Sodium hypochlorite	>6.7	>7.0	>6.7
800 ppm Sodium hypochlorite	>6.7	>7.0	>6.7
5 percent Acetic acid	>6.7	4.5	>6.7
8 percent Trisodium phosphate	>7.0	6.8	>7.0
1 percent Sodium metabisulfite	0	0	0
Deionized water	0.1	0	0.6

Tamblyn, *et al.*, 1997

tion equipment and reducing risks due to the presence of raw chemicals. One such product is ConSeal International's (Longwood, Fla.) ZyDox Anthium Dioxide.

Subsequent to Dr. Waldroup's presentation has been the USDA clearance in January of a patented process of involving the combination of sodium chlorite with acid to produce an acidified chlorous acid mist applied prior to the chiller (see page 32, *Newly Approved Bactericide Applied in Misting Chamber*). At the meeting she stated that if one has a serious chronic problem with salmonella (where salmonella keeps cropping up), the use of chlorine dioxide is probably the best strategy.

### Trisodium Phosphate

Trisodium phosphate (TSP) relies on its alkalinity and emulsifying properties for effectiveness. According to manufacturer Rhodia, TSP has two important modes of action. First, the highly alkaline (pH = 12-13) solution removes fat films from the surface of the carcass. Secondly, when the alkaline solution comes into contact with the pathogen, a disruption and lysing of the cell membrane occurs. Since the outer membrane is rich in fatty molecules, the wall is torn apart.

In Rhodia's Assur-Rinse program, a two-part, on-line processing system is used. It consists of a vigorous water wash followed by a patented rinse located just prior to the chiller. Figure 1 illustrates where the TSP program fits into the processing line. The process offers the following advantages: reduced manpower demands for off-line processing, increased yield through reduction in trim loss and increased line efficiency combining fewer slowdowns

with increased numbers of birds being chilled.

One operation that has reported success with the Rhodia TSP system is Choctaw Maid, Carthage, Miss. Says Processing Director Duffy McKenzie, "We have been very pleased with the results of the system." Microbiological assays are run for *E. coli* and salmo-

nella post-chill, and the results have been excellent, according to Mr. McKenzie. He goes on to state that off-line reprocessing has been virtually zero and that the system has more than paid for itself. The firm reports that it has had no problem with wastewater disposal with relation to phosphates.

### Ozone Water Treatment

In June 1997, ozone was granted GRAS status and is currently receiving attention from poultry processors. This highly reactive form of oxygen (O<sub>3</sub> instead of O<sub>2</sub>) is dissolved in water. Being a powerful oxidizer, the ozone binds to the carbon atoms in the bacterial cell wall, therein compromising the integrity of the cell wall and killing the microorganism. Ozone has 150 percent of the oxidizing potential of chlorine.

**Table 4.**

Organism	Associated Foods	Frequency of Disease
<i>Campylobacter jejuni</i>	Frequently contaminates raw chicken. Surveys show 20 to 100 percent of retail chicken contaminated. Also found in shellfish, livestock, pets, raw milk and non-chlorinated water.	Leading cause of bacterial diarrhea in the U.S. Estimates are 2 to 4 million per year. Fewer than 500 organisms can cause illness. More frequent in the summer months than in winter.
<i>Listeria monocytogenes</i>	Frequently associated with raw milk, cheese, raw vegetables, ferments raw meat sausages, raw and cooked poultry and fish.	CDC data indicates at least 1850 cases in the U.S., 424 of which are fatal. Difficult to determine. Infective dose is unknown but probably <50.
Salmonella spp.	Raw meats, poultry, eggs, milk and dairy products, fish, shrimp, yeast, coconut, sauces and salad dressings, cake mixes, cream-filled desserts, dried gelatin, peanut butter, cocoa and chocolate	Estimates are between 2 to 4 million cases annually in the U.S. Infective dose as low as 15-20 cells.
<i>Staphylococcus aureus</i>	Meat and meat products; poultry and egg products; salads involving eggs, tuna, potato and macaroni; cream filled bakery products; sandwich fillings; and milk and dairy products. FDA states that food requiring considerable handling during preparation and that are kept at slightly elevated temperatures are frequently involved.	Unknown.
<i>Escherichia coli</i> Enteropathogenic strains (EPEC) Enteroinvasive strains (EIEC) Enterotoxigenic strains (ETEC)	Primarily raw beef or chicken. Can be associated with any food exposed to fecal contamination.	On a worldwide basis associated with local sanitation practices. Infective dose very low for infants.
<i>Escherichia coli</i> O157:H7	Undercooked or raw hamburger, raw milk. Improperly handled food. Person-to-person contact.	Not common, but highly virulent. Found worldwide with cases most commonly occurring in the summer months.

Source: FDA Bad Bug Book (<http://cfsan.fda.gov/~mow>); CDC (<http://www.cdc.gov/ncidod/diseases>); National Livestock (<http://www.exnet.iastate.edu/pages/familles/fs>).

With the granting of GRAS status to ozone, a number of innovative approaches are now hitting the market. While many of the systems are in the testing or prototypical stage, several units are currently in commercial operation (see *Ozone: An Old, But New, Technology*).

One of the key advantages to ozonation is a reduction in the water utilization. When properly utilized, ozonation is extremely effective in killing bacteria. Additionally, it offers the opportunity to reduce water consumption in the chilling process through recycling.

### Irradiation

With the controversy about *E. coli* in hamburger meat, the subject of irradiation has received considerable press. The fact is that irradiation has been an

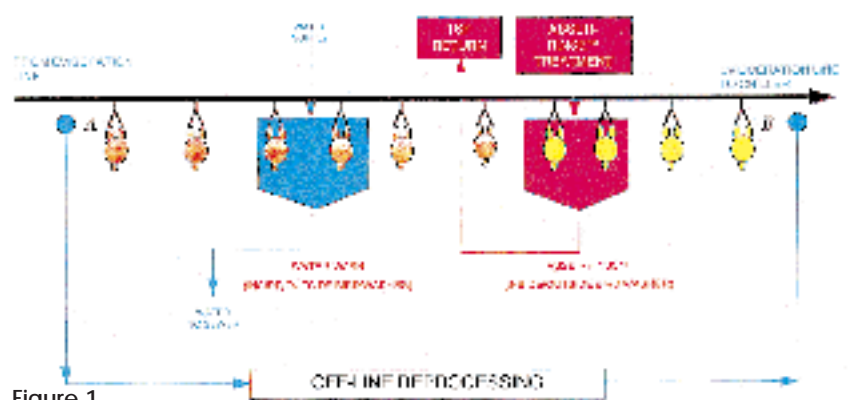


Figure 1

option for the poultry industry; but between high costs and consumer resistance, it has not developed into a viable alternative at this juncture.

The process involves bombarding the product with ionized energy which creates positive and negative charges that damage large molecules critical to

the survival of the organism. In the process, product must be taken to the irradiation site (a serious limitation) whereupon the product is exposed to a stream of gamma rays produced by cobalt-60. The *Chicago Tribune* (December 8, 1997) reported that Gray-Star, a firm in Mt. Arlington, N.J., is developing a unit capable of being installed on-site in a processing plant using cesium-137. The prototype is expected to be completed this year.

### Steam

Steam offers an alternative to irradiation, but the problem is that it is not a viable alternative for fresh product. When chicken is exposed to steam for as little as two seconds, the skin starts to cook. The mode of action involves the steam coagulating the cells of the pathogens, making them rigid and thereby killing them.

### Looking to the Future

Where does the industry go from here? Dr. Waldroup has stressed the idea that the key to addressing food safety today and in the future centers on education. At the National Meeting on Poultry Health & Processing she stated, "Education will probably be the biggest factor to decreasing cases of foodborne illness."

She points out that 82 percent of the cases and 72 percent of the outbreaks of foodborne illness occur outside of the home. For society to attain the goals of a safe food supply, it is essential that our educational system and the employers of food companies teach people to wash their hands and how to

Symptoms	Target Populations	Prevention
Incubation period: 2-5 days Diarrhea (either watery or sticky); fever, abdominal pain, nausea, headache, and muscle pain. Can be associated with arthritis and hemolytic uremic syndrome.	Almost all segments of the population, but children under 5 and young adults (15-29 years old) are more frequently affected.	Routine sanitation procedures for hand and utensil washing. Cold foods should be kept at or below 40 F. Cook ground poultry to uniform internal temperature of 165 F; poultry, 170 F. Chlorination of water. Some data indicates that it can be spread through drinking water in a poultry flock.
Incubation period: probably greater than 12 hours. Septicemia, meningitis, encephalitis and intrauterine or cervical infections. Generally preceded by flu-like symptoms.	Pregnant women (20X more likely than other healthy adults), newborns, immunosuppressed individuals, cancer patients.	Routine sanitation procedures for hand and utensil washing. Will grow in refrigerated temperatures and is fairly tolerant to freezing. Cook ground poultry to uniform internal temperature of 165 F; poultry, 170 F.
Incubation period: 6-48 hours. Acute symptoms include nausea, vomiting, abdominal cramping, fever, headache, and minimal diarrhea.	All groups are susceptible, but especially noteworthy are elderly, infants and infirmed. AIDS patients are very susceptible.	Routine sanitation procedures for hand and utensil washing. Cold foods should be kept at or below 40 F. Cook ground poultry to uniform internal temperature of 165 F; poultry, 170 F.
Rapid and acute onset. Symptoms include nausea, vomiting, retching, abdominal cramping and prostration. In severe cases, headaches, muscle cramping and transient changes in blood pressure and pulse rate may occur.	All groups are susceptible.	Food handling and further processing by hand are the areas of concern. Use stringent routines for hand washing and sanitation under these conditions.
EPEC: Watery or bloody diarrhea. EIEC: Mild form of dysentery. ETEC: Watery diarrhea, abdominal cramps, low-grade fever, nausea, malaise.	EPEC: Commonly infants. EIEC: All populations. ETEC: Infants and travelers to underdeveloped countries.	Routine sanitation procedures for hand and utensil washing.
Severe cramping and diarrhea (initially watery, becoming bloody). Occasional vomiting; low-grade or no fever. Complications include hemolytic uremic syndrome (HUS).	All populations are susceptible; larger outbreaks have occurred in institutional settings.	Routine sanitation procedures for hand and utensil washing. Cold foods should be kept at or below 40 F. Cook ground poultry to uniform internal temperature of 165 F; poultry, 170 F. Reheat foods to 160 F or until steaming hot; keep hot foods above 140 F.

and Meat Board (<http://www.agen.ufl.edu/~foodsaf>); Iowa State University

### Newly Approved Bactericide Applied in Misting Chamber

Novus International received approval from USDA in January for its Sanova Food Quality System for use in poultry processing. The new system integrates the development of a new bactericide with an application system in conjunction with the Provus process control technology.

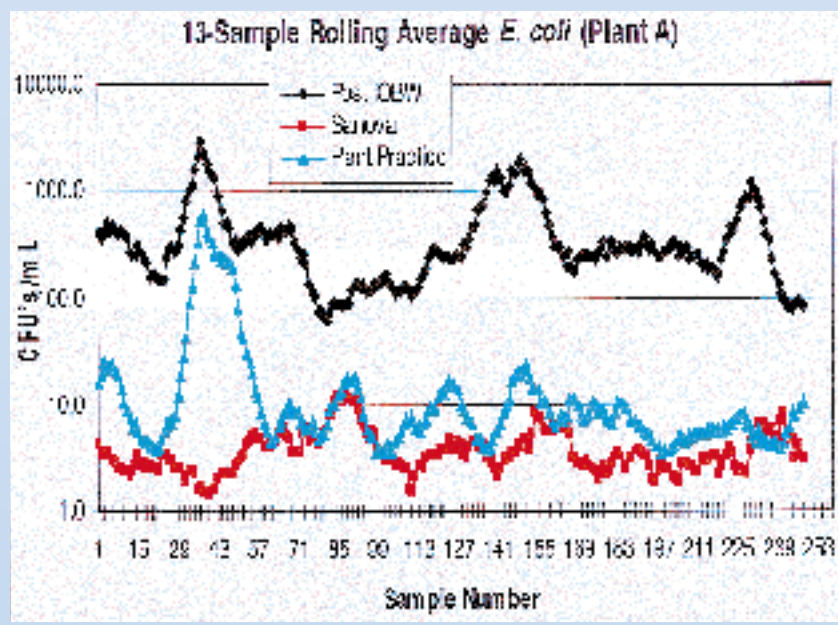
Collaborating with the Redmond, Wash.-based company Alcide, Novus's program is based on the acidification of sodium chlorite. When chlorite is exposed to acid (in this case, citric acid), the resulting compound has strong oxidizing properties that disrupt bacterial membrane function. It is important to note that the system kills microorganisms without the so-called Lazarus effect (that is, where the bacteria are simply injured but come back to life). Testing immediately after chemical application can give false readings that organisms are dead when, in reality, they have the ability to rebound which can be observed a couple of days later.

#### $\text{NaClO}_2 + \text{H}^+ = \text{HClO}_2$ (Chlorous acid)

The system involves positioning a misting chamber immediately prior to the chiller, whereupon each bird is misted with 3-5 ounces of the bactericide having a concentration of about 1,000 ppm sodium chloride.

The program is an integrated one, whereby Novus provides the equipment and process control technology at no capital cost to the poultry processor. In addition to providing the application system, the company's Automated Inventory Management System (AIMS) is incorporated. Through the process control technology, the system provides data which can help in compliance with the new HACCP model. In addition to monitoring and controlling the system, the technology monitors and documents performance of other key processes in the facility, such as IOBW and chiller performance.

In the trials submitted to USDA, the true value of the product was that it uniformly reduced bacterial levels across a wide variety of flock contamination loads. The trials showed that the birds coming into the line varied greatly as to the potential for contamination. Traditional procedures generally lowered the contamination, but the spikes in finished product load were correlated with the initial bacterial load (see figure below). The Sanova system produced a flatter, consistently lower bacterial load. □



keep food sufficiently cool or hot to protect the public.

HACCP redefines how we look at poultry processing. Concurrent with the focus on microbial detection through processing, USDA is changing its paradigm on equipment and automation approval. Says Jerry Dyer of Automation Planners, Inc., "A combination of the old and new technologies focusing on providing a cleaner bird will be the answer for the future. In the past USDA has been slow to allow product innovation; but these attitudes have changed. They are now encouraging it. The new rules open new avenues for equipment technology. In fact, a lot of the equipment now on the market will become obsolete.

"In the past," Mr. Dyer continued, "we had to approach everything we did with a high degree of familiarity to USDA so it could be approved. Now we have a more open structure on what the processes can be. True innovators today will rise to the top, and the new systems will combine equipment and process control technology with an increasing focus on providing cleaner birds. That involves incorporating antimicrobials treatments with new ways of eliminating exposure to contaminants. In fact, our industry has proven that when new technologies arise and are proven, they are rapidly incorporated into an increasingly complex process of providing clean and safe products."

Looking to the future, the poultry industry will have the opportunity to adopt a number of technological improvements which are hitting the market with increasing rapidity. HACCP has changed the way the industry does business. As with any change, it offers headaches but also new opportunities. While a zero tolerance is never attainable, the industry has new tools to address the challenges. ■

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## Ozone: An Old, But New, Technology

The antimicrobial effects of ozonation of water have been clearly demonstrated, but its use in poultry processing is in its infancy. The first applications of this technology will be focused on the chiller, but down the road its applications will spread throughout the processing line.

**Savings through recycling and energy reduction.** American Water Purification (Wichita, Kan.) has developed a system that focuses on filtering chiller water, treating the filtered water with ozone and then recycling it to the chiller. The system leaves the original flow system intact so that if the treatment unit goes off-line for any reason, plant operation can continue. All of the equipment in the process is located outside of the plant with flow rates and levels fully automated. Company President William Graham cites the new technology as a way to combine effectively sanitizing the water, dramatically lowering water consumption and reducing energy consumption through the recycling of water that is already chilled, therein reducing the refrigeration requirements of the chilling system.

As far as investments and payback are concerned, Mr. Graham explains that the system is based on a licensing program, the cost of which is based on the water saved. The system is currently being used in Gold Kist's Carrollton plant as a pilot project. Gold Kist reportedly plans to install the ozonation system in its Ellijay plant because of a need to reduce the amount of waste water sent to the city waste treatment plant.

**Filtration with treatment.** In January, BOC Gases (Murray Hill, N.J.) introduced the Macron Loop system which disinfects process water. Water from the chiller bath is moved by a sanitary pump through the mechanical filtration device (Macron filter) where particles as small as 25 microns are removed. Following filtration, the water is injected with ozone gas and the sanitized water is recirculated back to the chiller.

The system recycles water at a rate of 800 gallons per minute, therein changing water over every half hour. The system allows the processor to push through more water while using less total water through recycling.

The BOC system was extensively tested during the approval process at the ConAgra plant in Gainesville, Ga.

**Focusing on the final wash.** A new technology currently being developed by Cooling & Applied Technology (Russellville, Ark.) focuses on the final wash of the birds in the processing line. Using the rationale that a scrubbed bird is a clean bird, the technology essentially uses water pressure (with ozonated water) to scrub the carcass. This technology reflects the changing focus of poultry processors to evaluate other areas of the line beyond the chiller.

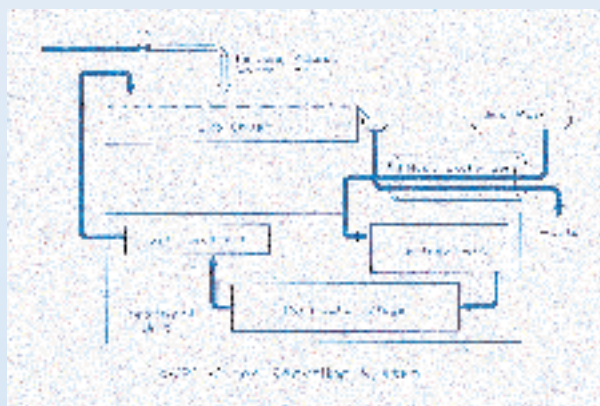


Figure 1. AWP flow diagram



Figure 2. Before (right) and after (left): the filtration and treatment with ozone of chiller water with the AWP system

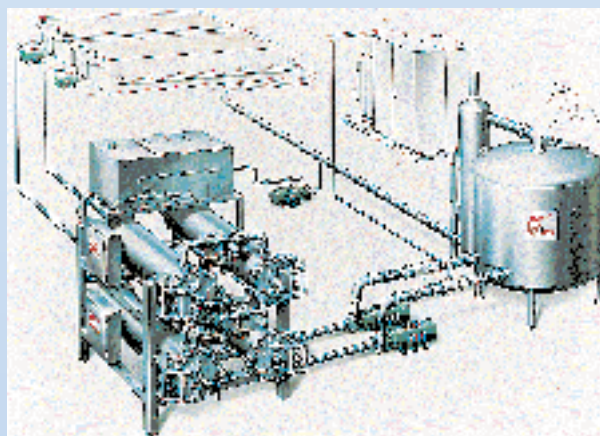


Figure 3. BOC flow diagram

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