RECEIVED JAN 5 2004

Applegate Farms®

10 County Line Road Branchburg, New Jersey 08876
Tel 908-725-5800 Fax 908-725-3383
applegatefarms.com

Robert Pooler
National Organic Standards Board
Agricultural Marketing Specialist
USDA, AMS, TM, NOP
Room 2510 South, Ag Stop 0268
PO Box 96456
Washington, DC 20090-6456

Dear Mr. Pooler:

Enclosed are duplicate copies of a petition for the inclusion of Sodium Lactate and Potassium Lactate on the NOP Approved Materials List. I hope you find every thing needed for the TAP review. If you should have any questions, please feel free to contact me at any time either by phone - 908-725-5800 or by e-mail - chris.ely@applegatefarms.com

Sincerely,

Christopher Ely

Antibiotic Free • No Nitrites • Organic

Petition for the Inclusion of Sodium Lactate and Potassium Lactate into the National Organic Program Materials List

Name: Sodium Lactate or Potassium Lactate

Category: Nonagricultural (non organic) substances in or on processed products labeled as "organic" or "made with organic (specified ingredients)."

Manufacturers: Purac America, 111 Barclay Boulevard Lincolnshire, IL 60069; Trumark Co., 830 East Elizabeth Ave., Linden, New Jersey 07036

Use: Both Sodium Lactate and Potassium Lactate are used in meat processing as a pathogen inhibitor. Product comes as a liquid and is added to meat as an ingredient at the rate of 1% to 4.8% as prescribed by USDA-FSIS regulations, depending on the product. Whether one uses sodium lactate or potassium lactate is at the discretion of the processor or by the requirements of the recipe - i.e. Low sodium products.

Source and Manufacturing: Sodium lactate is the combination of sodium hydroxide and lactic acid; potassium lactate is the combination of potassium hydroxide and lactic acid. The manufacturing of sodium lactate or potassium lactate is the same. The potassium/sodium hydroxides used are synthetic from sources that are excluded from sewage sludge, irradiation and GMOs (7 CFR Part 205.301(c)). The lactic acid used is produced by the fermentation of lactic acid starter cultures not from GM methods, and sugar from non GM beets.

Sodium Hydroxide, Potassium Hydroxide and Lactic Acid are already approved by the NOSB.

Either hydroxide is combined with the lactic acid (base + acid) in a very controlled environment that constantly monitors the process and temperature of the reaction. No other substances are added to this process to aid the reaction. The final product is a liquid of either sodium lactate or potassium lactate and water.

Reason for Use: The USDA-FSIS has declared in 9 CFR Part 430, "Control of Listeria monocytogenes in Ready-to-Eat Meat and Poultry Products; Final Role", that "On the question of a 'Zero Tolerance' for L. Monocytogenes and particularly with respect to RTE products that support growth of the pathogen, FSIS currently regards any amount of the organism as a product adulterant." All meat and poultry companies are now held liable for any product adulteration from pathogens, even if the product were to be temperature/storage abused by a distributor, store or consumer. Adulteration can occur at multiple points during production and storage of a processed meat product. In order to protect the consumer the addition of an antimicrobial that works over the shelf life of the product is crucial. It is common to find temperatures above 37 degrees F throughout the supply chain and the consumer is often the worst violator with regards to managing temperature. Small increases in temperature foster exponential pathogen growth. If there is nothing in the product that works to inhibit this growth the probability of food borne illness increases substantially. It only takes a couple microbes of any one pathogen to flourish under the right conditions. Currently, detection capabilities at the processing level are uncapable of detecting every microbe. Also, there is no known post-lethality treatment that guarantees a

perfect kill, therefore building in a "hurdle" technology that inhibits growth brings needed assurance for the consumer.

Today, all federally inspected meat and poultry facilities must have an FSIS approved HACCP and SSOP program validated by scientific assessment carried out by the USDA and all recognized associations. It is only these approved guidelines and policies that may be used in a HACCP program and targeted verification protocol that validates the risk assessment of pathogens and the post-lethality of these pathogens on and in RTE meat and poultry products. There is no known post lethal treatment to date that can guarantee total kill of all known pathogens, including irradiation, for fresh or frozen ready-to-eat meat and poultry products.

Unless the addition of antimicrobial products are allowed in RTE meat and poultry products, even under the most sanitary, highly monitored facilities, we will be at risk with food borne illnesses or as the perhaps even pathogens, which can be fatal

L. Monocytogenes is one of the most prolific pathogens that is able to withstand high and low temperatures, extreme pH and low oxygen environments. Sodium and Potassium Lactates are one of few known antimicrobials (sodium diacetate is another) and recognized by the USDA-FSIS as being validated through scientific studies as to inhibit the growth of L. Monocytogenes, along with E.coli, Salmonella and other pathogens. Lactates are also the only know antimicrobials, other then sodium nitrate/nitrite that controls Clostridium Botulinum in meats. It should be notes that the sole propose for the inclusion of nitrites and nitrates in meats was originally to control botulism.

Lactates are also naturally produced in the human body. Not only is there about 1% naturally occurring in our system, lactate is produced during exercise and used by our body through the Cori cycle. (see enclosed printout from Texas A&M).

USDA Risk Assessment

Federal Register

Friday,
June 6, 2003

Part V

Department of Agriculture

Food Safety and Inspection Service

9 CFR Part 430

Control of Listeria monocytogenes in Ready-to-Eat Meat and Poultry Products; Final Rule

DEPARTMENT OF AGRICULTURE

Food Safety and Inspection Service

9 CFR Part 430

[Docket No. 97–013F]

RIN 0583–AC46

Control of *Listeria monocytogenes* in Ready-to-Eat Meat and Poultry Products

AGENCY: Food Safety and Inspection Service, USDA.

ACTION: Interim final rule.

SUMMARY: The Food Safety and Inspection Service (FSIS) is amending its regulations to require that official establishments that produce certain ready-to-eat (RTE) meat and poultry products prevent product adulteration by the pathogenic environmental contaminant *Listeria monocytogenes*. In particular, under these regulations, establishments that produce RTE meat and poultry products that are exposed to the environment after lethality treatments and that support the growth of *L. monocytogenes* will be required to have, in their hazard analysis and critical control point (HACCP) plans, or in their sanitation standard operating procedures or other prerequisite programs, controls that prevent product adulteration by *L. monocytogenes*. The establishments must share with FSIS data and information relevant to their controls for *L. monocytogenes*. The establishments also must furnish FSIS with information on the production volume of products affected by the regulations. The establishments may make claims on the labels of their RTE products regarding the processes they use to eliminate or reduce *L. monocytogenes* or suppress or limit its growth in the products.

DATES: This interim final rule is effective on October 6, 2003.

Comments on the information presented under "Paperwork Reduction Act" must be received by August 5, 2003.

Recognizing, however, that some approaches to *L. monocytogenes* control set out in this interim final rule are novel, FSIS will accept comments on the rule until December 8, 2004, for the purpose of reviewing and evaluating the effectiveness of these approaches.

ADDRESSES: One original and two copies of each comment should be sent to FSIS Docket #97–013F, U.S. Department of Agriculture, Food Safety and Inspection Service, Room 102 Cotton Annex, 300 12th Street, SW., Washington, DC 20250–3700. Comments will be available for public inspection in the Docket Clerk's Office between 8:30 and 4:30 p.m., Monday through Friday.

FOR FURTHER INFORMATION CONTACT: Daniel L. Engeljohn, Ph.D., Acting Assistant Deputy Administrator, Policy Analysis and Formulation, Office of Policy, Program Development, and Evaluation, Food Safety and Inspection Service, U.S. Department of Agriculture (202) 205–0495. Copies of references cited in this document are available in the FSIS Docket Clerk's Office, Room 102, Cotton Annex, 300 12th Street, SW., Washington DC 20250–3700. The Office is open 8:30 a.m. to 4:30 p.m., Monday through Friday.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Background
II. Listeria monocytogenes
III. Events leading up to the proposed rule
Outbreaks and recalls 1999 reassessment notice
FSIS action plan
FDA/FSIS draft risk ranking
IV. Proposed rule provisions on L. monocytogenes
Compliance guidance
Opportunity for public comment
Public meetings on Listeria
V. FSIS risk assessment of L. monocytogenes in RTE meat and poultry products
VI. Comments on the proposal and FSIS response
VII. The Interim Final Rule: Control of L. monocytogenes
Alternative 1
Alternative 2
Alternative 3
Estimates of annual production volume
Labeling incentive
New and existing regulatory requirements
VIII. Implementation
Implementation strategy
New directive for FSIS inspection program employees
IX. Consumer outreach effort
X. Executive Order 12866 and Effect on Small Entities
Summary of final regulatory impact analysis
XI. Paperwork Reduction Act and Government Paperwork Elimination Act
XII. Executive Order 12988
XIII. Additional public notification
XIV. Final Regulations
Appendix A

I. Background

The Food Safety and Inspection Service (FSIS) administers the Federal Meat Inspection Act (FMIA; 21 U.S.C. 601 *et seq.*) and the Poultry Products Inspection Act (PPIA; 21 U.S.C. 451 *et seq.*) to ensure that meat, poultry, and egg products prepared for distribution in commerce are wholesome, not adulterated, and properly marked, labeled, and packaged. The FMIA and PPIA prohibit anyone from selling, transporting, offering for sale or transportation, or receiving for transportation in commerce, any adulterated or misbranded meat or poultry product (21 U.S.C. 610, 458).

Under the Acts, a meat or poultry product is adulterated if, among other circumstances, it bears or contains any poisonous or deleterious substance that may render it injurious to health (21 U.S.C. 601(m)(1), 453(g)(1)); if it is for any reason unsound, unhealthful, unwholesome, or unfit for human food (21 U.S.C. 601(m)(3), 453(g)(3); or if it has been prepared, packed, or held under insanitary conditions whereby it may have been rendered injurious to health (21 U.S.C. 601(m)(4), 453(g)(4). Such a product is misbranded if, among other circumstances, it fails to bear directly or on its container the official inspection legend (*e.g.*, for meat products, "U.S. Inspected and Passed" plus the official establishment number) prescribed in the regulations (21 U.S.C. 601(n)(12), 453(h)(12)). The Acts require FSIS to carry out an inspection of meat, meat food products, and poultry products to ensure that the products are not adulterated (21 U.S.C. 606, 455), and if the products are found upon inspection to be not adulterated, they must bear directly or on their containers the official inspection legend (21 U.S.C. 606, 607, 457).

The Acts give FSIS broad authority to promulgate such rules and regulations as are necessary to carry out the Acts (21 U.S.C. 621, 463). The Acts require FSIS to prescribe rules and regulations governing the sanitary conditions under which the establishments that produce these products are to be operated (21 U.S.C. 608, 456).

On February 27, 2001, FSIS proposed (66 FR 12589) to establish several new requirements for the processing of ready-to-eat (RTE) and other meat and poultry products. The Agency proposed food safety performance standards for all RTE and all partially heat-treated meat and poultry products. The proposed performance standards set both levels of pathogen reduction and limits on pathogen growth that official meat and poultry establishments must achieve in order to produce products that are not adulterated. FSIS also proposed to allow the use of customized, plant-specific processing procedures and to eliminate its regulations that require that both RTE and not-ready-to eat pork and products containing pork be treated to destroy trichina (*Trichinella spiralis*).

Finally, FSIS proposed environmental testing requirements intended to verify measures to reduce the incidence of *L. monocytogenes* in RTE meat and poultry products. Specifically, FSIS proposed to

require establishments that produce RTE meat and poultry products to test food contact surfaces for *Listeria* species to verify that establishments were controlling the presence of *L. monocytogenes* within their processing environments. Under the proposal, establishments that developed and implemented HACCP controls for *L. monocytogenes* would be exempt from these testing requirements because the HACCP regulations require on-going monitoring and verification to demonstrate that the food safety system is working.

In this interim final rule, FSIS is amending its regulations only in regard to the control of *L. monocytogenes* in RTE products. FSIS plans to address the other proposed provisions in future **Federal Register** publications. In view of recent outbreaks of foodborne listeriosis, as well as recent recalls of meat and poultry products adulterated by *L. monocytogenes*, the Agency has decided to adopt these regulations before completing action on the other provisions of the proposal.

II. Listeria monocytogenes

L. monocytogenes is a pathogenic bacterium found in the environment (*e.g.*, in soil, water, and vegetation and on the surfaces of equipment, floors, and walls) and is often carried by healthy animals (including humans). *L. monocytogenes* is spread very easily by direct food contact with a contaminated surface, and it can survive and grow in a refrigerated, packaged RTE product.

L. monocytogenes grows under low-oxygen conditions and at low refrigeration temperatures and survives for long periods of time in the environment, on foods, in processing plants, and in household refrigerators. Although frequently present in raw foods of both plant and animal origin, it also can be present in cooked foods because of post-processing contamination. Consumption of food contaminated with *L. monocytogenes* can cause listeriosis. Listeriosis is a potentially fatal disease in newborns, the elderly, and persons with weakened immune systems, such as those with chronic disease or human immunodeficiency virus (HIV) infection or those taking chemotherapy for cancer. Listeriosis is also a major concern in pregnant women. Even though symptoms may be relatively mild in the mother, the illness can be transmitted to the fetus, causing illness or fetal death.

Each year, according to the Centers for Disease Control and Prevention (CDC), *monocytogenes* causes an estimated ,493 cases of listeriosis. Of these, 2,298 persons are hospitalized, and 499 persons die. The case-fatality rate is high across the whole population—20 deaths per 100 cases of illness. Epidemiologic surveillance data show that the case-fatality rate varies by age, with a higher case-fatality rate among newborns and the elderly.[1]

L. monocytogenes is one of several foodborne pathogens that have been a special focus of public health strategies, such as Healthy People 2010. Organized by the Department of Health and Human Services (HHS), Healthy People 2010 is a comprehensive, nationwide health promotion and disease prevention agenda for increasing the quality and years of healthy life. The food safety objectives of Healthy People 2010 include infection reduction targets for pathogens of concern. The 2010 target for *L. monocytogenes* is to reduce by 50 percent the rate of illnesses below the 2001 level of 0.5 cases per 100,000 population.

A number of factors can cause or contribute to *L. monocytogenes* contamination of RTE meat and poultry products in a meat or poultry processing establishment. First, if the pathogen is already present in product ingredients, a processing error, such as incorrect formulation or inadequate processing time or temperature, can result in the production of products containing live organisms. Second, a product that has undergone a successful lethality treatment can be contaminated by biofilms on food-contact surfaces of equipment used for processing, handling, or packaging the product. The product can also be exposed to environmental contamination or cross-contamination in the post-lethality processing environment. One cause of cross-contamination can be plant construction in the post-lethality area of the establishment, unless precautions are taken to protect the products during the period of construction. Serious outbreaks of listeriosis have occurred because of the failure to take such precautions during facilities construction or remodeling.

Additional causes of contamination or cross contamination can be poor facilities design or plant equipment layout. Cross-contamination can occur if the flow paths of raw product and finished products cross or if vehicle or personnel traffic from outside the plant or from a raw-product area of the plant enters an area where exposed finished products are handled. Contamination or cross-contamination also can occur if processing equipment has not been designed for easy cleaning, or if equipment or facilities have hard-to-reach niches that can harbor *L. monocytogenes* or other pathogens.

[1] Mead, P. S., L. Slutsker, V. Dietz, L. F. McCraig, S. Bresee, C. Shapiro, P. M. Griffin, and R. V. Tauxe. 1999. Food-related illness and death in the United States. *Emerging Infectious Diseases* 5:607–625.

III. Events Leading Up to the Proposed Rule

Outbreaks and Recalls

During the 1980's, *L. monocytogenes* began to emerge as a problem in processed meat and poultry products. FSIS and FDA worked with processing plants to improve their procedures and emphasized a "zero tolerance"—no detectable levels of viable pathogens—for the organism in RTE products. Between 1989 and 1993, the rate of illness from *L. monocytogenes* declined 44 percent.

In the fall of 1998, State health departments and the CDC investigated an outbreak of foodborne illness in which hotdogs and, possibly deli (luncheon) meats, were implicated. CDC and FSIS investigators isolated the outbreak strain, a strain of *L. monocytogenes*, from an opened and previously unopened package of hotdogs manufactured by a single plant. CDC eventually reported 101 illnesses, 15 adult deaths, and 6 stillbirths or miscarriages associated with the outbreak.

Another outbreak of listeriosis occurred between May and December 2000 and was spread over 10 States. CDC linked a strain of *L. monocytogenes* to 29 illnesses—8 perinatal and 21 non-perinatal—resulting in 4 deaths and 3 in miscarriages or stillbirths. Subtyping by pulsed-field gel electrophoresis (PFGE) showed the *L. monocytogenes* strains to be indistinguishable from one another.

The outbreak was linked to eating turkey deli meat. Thirteen stores and delicatessens where patients reported purchasing turkey meat obtained their turkey meat from at least 27 federally inspected establishments. Two establishments were linked to 10 of 11 patients. FSIS traced the implicated turkey meat to a Texas poultry processor.

1999 Reassessment Notice

In 1999, with the emergence of an especially virulent strain of *L. monocytogenes*, the Agency concluded that many establishments should reassess their HACCP plans. FSIS published in the **Federal Register** a Notice (64 FR 28351; May 26, 1999) advising manufacturers of RTE meat and poultry products of the need to reassess their HACCP plans to ensure that the plans were, in fact, adequately

addressing *L. monocytogenes*. If the reassessment revealed that *L. monocytogenes* was a hazard reasonably likely to occur in an establishment's production process, the establishment would have to address the hazard in its HACCP plan.

The same month, FDA and FSIS announced plans to conduct a quantitative microbial risk assessment to determine the extent of consumer exposure to foodborne *L. monocytogenes* in RTE foods (64 FR 24661; May 7, 1999).

FSIS Action Plan

A May 5, 2000, Presidential directive on *L. monocytogenes* in RTE foods revised the Healthy People 2010 target date for reducing illnesses caused by the pathogen up to 2005 and set other objectives. HHS and USDA responded to this directive with an eight-point action plan providing for consumer, health-care provider, and industry education; redirection of enforcement strategies, including increased microbial sampling; enhanced disease surveillance; coordinated research activities; and proposing new regulations. For its part, FSIS announced its intention to publish a proposed rule that would, among other things, require establishments to conduct environmental testing for *Listeria* species in order to verify the effectiveness of their sanitation standard operating procedures (Sanitation SOPs).

FDA/FSIS Draft Risk Ranking

FDA and FSIS made public a preliminary draft of a risk ranking in January 2001 (66 FR 5515; January 19, 2001). The risk ranking (*see http://www.foodsafety.gov/dms/lmrisk.html*) estimated the relative risks of serious illness and death from listeriosis that may be associated with consumption of different types of RTE foods. The risk ranking did not cover listerial gastroenteritis, a less serious infection with mild flu-like symptoms. The risk ranking (1) estimated the potential level of exposure of three age-based U.S. population groups to *L. monocytogenes* contaminated foods in 20 food categories and (2) related this exposure to public health consequences. The food categories studied included foods with a history of *L. monocytogenes* contamination. The models used in the risk ranking provided a means of predicting the likelihood that severe illness or death will result from consuming foods contaminated with this pathogen. Estimates were made of the relative risks posed by the food categories, but the risk ranking did not predict the precise public health consequences attributable to any particular contaminated food.

The foods considered in this risk ranking were RTE foods that are generally eaten without being cooked (*e.g.*, cheese) or are typically reheated (*e.g.*, frankfurters) before consumption. The main categories considered were seafood, produce, dairy, meat, and combination foods. The population groups evaluated were: (1) perinatal, including fetuses and neonates from 16 weeks after fertilization to 30 days postpartum. These are pregnancy-associated cases where exposure occurs most often *in utero* as a result of foodborne *L. monocytogenes* infections of the mothers during pregnancy and may result in spontaneous abortions, stillbirths, and neonatal infections; (2) elderly, that is, individuals who are 60 or more years of age; and (3) the intermediate-age group, including the remaining population, both healthy individuals (with very low risk of severe illness or death from *L. monocytogenes*) and certain susceptible population groups.

The population groups included individuals with increased susceptibility to listeriosis, such as acquired immune deficiency syndrome (AIDS) patients or individuals taking drugs that suppress the immune systems (*e.g.*, cancer or transplant drugs). Individuals within these susceptible population groups account for most of the cases of listeriosis within the intermediate-age group. The risk ranking focused on the overall burden of listeriosis on public health and includes the occurrence of both sporadic illnesses (*i.e.*, illnesses not associated with a documented outbreak) and outbreak illnesses.

The results of the risk ranking indicated that certain RTE meat and poultry products presented a relatively moderate to high risk for listeriosis. These included pâtés and meat spreads, deli meats, hotdogs, and deli salads containing meat or poultry products. Further, there was a significant opportunity for recontamination of RTE meat and poultry products in the processing establishment.

IV. Proposed Rule Provisions on *L. monocytogenes*

The Agency concluded that many establishments were not effectively implementing HACCP plans and Sanitation SOPs to prevent *L. monocytogenes* from contaminating the RTE product in the post-lethality processing environment. The Agency therefore resolved to proceed to rulemaking to correct the problem. In February 2001, FSIS issued a proposed rule that would require that establishments that produce post-lethality exposed RTE meat or poultry products conduct testing of food contact surfaces for *Listeria* species in areas of the establishments into which the products are routed after undergoing lethality treatment and before final product packaging. All establishments would be required to do this unless they had incorporated one or more controls validated to prevent, reduce to an acceptable level, or eliminate the *L. monocytogenes* from their products into their HACCP systems.

The proposed testing was intended to verify that the establishment's Sanitation SOP was preventing direct product contamination by *L. monocytogenes* after the products had undergone a lethality treatment. FSIS recognized that there is a significant risk for RTE meat and poultry products to become re-contaminated by *L. monocytogenes* if they came into contact with the pathogen, and that testing was necessary to verify that the procedures conducted under the Sanitation SOP had killed or eliminated the pathogen.

Under the proposal, if an establishment found that a food contact surface had tested positive for *Listeria* species, the establishment would have to take the corrective action necessary to properly clean the surfaces and to prevent product that may have become contaminated through contact with the surface from entering commerce.

Under the proposal, an establishment that had identified *L. monocytogenes* as a hazard reasonably likely to occur in its HACCP plan, and that had established CCPs for *L. monocytogenes*, was exempt from the proposed mandatory testing frequency requirement because HACCP regulations already require monitoring and verification, including testing frequency, as validated in the HACCP plan. An establishment that did not explicitly identify *L. monocytogenes* as a hazard reasonably likely to occur, but whose HACCP controls for biological hazards effectively prevented, eliminated, or reduced product contamination by the pathogen, would have had to make only minor amendments in its HACCP plan and supporting documentation to reflect that *L. monocytogenes* had been identified as a hazard addressed by the HACCP plan. In any case, if HACCP controls were implemented, the establishment would have to develop and validate the monitoring and verification procedures used to document the on-going effectiveness of the system. FSIS did not specify minimum monitoring and verification requirements for these processors.

The Agency has made it clear that, in its view, contamination with *L. monocytogenes* is a hazard reasonably likely to occur in all RTE meat and poultry products that are exposed to the processing environment post-lethality. Significant concerns about such contamination underlay the Agency's May 26, 1999, **Federal Register** Notice advising manufacturers of RTE meat and poultry products of the need to reassess their HACCP plans to determine whether the plans were appropriately addressing *L. monocytogenes*. In the proposal, however, the Agency acknowledged that, even though *L. monocytogenes* was a significant concern in RTE products, it may not be necessary to address this pathogen in the HACCP plan itself. FSIS acknowledged that this pathogen may be present but not necessarily likely to occur because the establishment had measures in place, such as Sanitation SOPs, that effectively prevented contamination by the pathogen in the food processing environment. An establishment might have incorporated the controls in its Sanitation SOP and thereby prevented the pathogen from posing a contamination hazard in the processing environment.

Consequently, to verify that such plants were effectively preventing environmental contamination, FSIS proposed to require that establishments without HACCP controls for *L. monocytogenes* test food contact surfaces for *Listeria* species at a frequency that was based on the relative size of the establishments. FSIS proposed that large establishments subject to the requirement conduct at least four such tests per line per month; small establishments at least two per line per month; and very small establishments at least once per line per month. A large establishment was one employing more than 500 employees; a small establishment from 10 to 499 employees; and a very small establishment one employing fewer than 10 employees and grossing less than $2.5 million in sales. These are the same size criteria the Agency had used in its 1996 final rule on HACCP systems (61 FR 38806).

The Agency solicited information on the proposed rule, including the efficacy of the testing frequencies, their potential cost to industry, the relationship between *Listeria* species on food contact surfaces and *L. monocytogenes* in product, and the various factors that might be important in devising effective testing protocols.

FSIS also proposed that establishments take certain actions after obtaining a positive food contact surface test result for *Listeria* species. An establishment with such a result would have to take the corrective action defined in its Sanitation SOP. The establishment would have to have in place procedures to determine which lots of product might be affected; to hold, sample, and test that product; and to dispose of affected product appropriately. FSIS acknowledged that some establishments would have to modify their Sanitation SOP corrective actions to include such elements.

FSIS requested comment on whether *Listeria*-positive test results on different food contact surfaces (such as surfaces that had been treated with a bactericide versus those that had not) should be treated differently; whether the Agency should establish more specific requirements on product sampling following a *Listeria*-positive test on a food contact surface; and whether an establishment should have to determine whether a *Listeria*-positive sample is *L. monocytogenes* before having to initiate product testing.

FSIS stated in the preamble of the proposal that if a sampled lot is found to be positive for *L. monocytogenes*, and the product from the lot is already in commerce, the Agency would request that the product be recalled. Further, the Agency stated, if product is found to be positive for *L. monocytogenes*, the establishment that produced it would likely have to establish controls for the pathogen within its HACCP plan.

FSIS noted that the two provisions addressing *Listeria* contamination contained in the proposed rule, HACCP and Sanitation SOPs, required specific daily action to ensure that product is not adulterated. FSIS stated that, as of the time of the proposal, it did not consider programs outside of Sanitation SOPs and HACCP to be sufficient to prevent the hazards associated with post-lethality contamination with *Listeria* in the manufacture of RTE products. For one thing, the Agency noted, documentation of corrective and preventive actions taken in such programs, known as GMPs (good manufacturing practices) or prerequisite programs, generally was not being provided to the Agency.

Compliance guidance: In the proposal, FSIS made a commitment to provide compliance guidance to establishments on testing frequencies and methodologies and appropriate corrective actions to take following positive tests on samples from food contact surfaces. FSIS also said it would publish guidance on available interventions (techniques for killing *L. monocytogenes*) establishments can implement as CCP's. FSIS made the draft compliance guidance available on its Web site after publication of the proposal.

Opportunity for Public Comment

FSIS provided a 90-day comment period. On April 13, 2001, FSIS published a **Federal Register** notice (66 FR 19102) extending the comment period an additional 30 days, through June 28, 2001, to provide opportunity for the public to comment on issues raised at a technical conference and public meetings that the Agency held May 8–10, 2001, on the proposed regulations. After the extended comment period expired, the Agency announced, in a July 3, 2001, **Federal Register** notice (66 FR 35112), that at the request of a consortium of trade associations, the Agency was reopening the comment period for an additional 30 days, until September 10, 2001. The consortium had said that it needed the additional time to review the large amount of scientific and economic data presented at the May 8–10 meetings, FSIS's draft compliance guidelines, and the draft FDA/FSIS risk ranking on the relationship between foodborne *L. monocytogenes* in RTE foods and human health.

Public Meetings on Listeria

During the development both of the proposal and this interim final rule, FSIS held a series of meetings with constituents and with technical and scientific experts on the problem of *L. monocytogenes* and how to control it. Some meetings were prompted by large-scale product recalls due to contamination with the pathogen or actual outbreaks of listeriosis.

In February 1999, following the late-1998 listeriosis outbreak and a recall of hotdogs and deli meats that had been contaminated with *L. monocytogenes*, FSIS held a public meeting on the food safety issues related to *L. monocytogenes* in meat and poultry products. At the meeting, industry and government procedures were discussed, including sampling programs for RTE products and the best ways to educate "at risk" populations about *Listeria*.

On May 15, 2000, FSIS held a public meeting to discuss current Agency initiatives to prevent human illness from *L. monocytogenes* in RTE meat and poultry products; the use of *Listeria* species as an indicator organism for *L. monocytogenes*; and the efficacy of environmental testing for *Listeria* species.

On May 8, 2001, FSIS held a public meeting to discuss scientific research and new technologies for detecting and controlling *L. monocytogenes* in RTE

meat and poultry products. At this meeting, FSIS requested data relevant to the proposed regulation regarding frequencies of testing for environmental *Listeria* species and the correlation of potential product contamination with production volume.

On November 18, 2002, FSIS held a public meeting to provide a forum for experts from government, academia, industry, and elsewhere to discuss current research and information related to improving the safety of RTE products. The topics discussed included the role of environmental and product testing, decontamination strategies, and consumer behaviors related to RTE foods. At the meeting, FSIS released a new draft directive (Directive 10,240.3, discussed below) on FSIS microbiological testing of RTE products for a number of organisms, including *L. monocytogenes*.

An additional public meeting was held February 26, 2003, to discuss an FSIS draft risk assessment which had been conducted to determine the likelihood that *L. monocytogenes* may contaminate RTE meat and poultry products during production and packaging processes. The Agency's draft risk assessment was released February 14, 2003, and was posted on the FSIS Web site (at *http://www.fsis.usda.gov/OPHS/lmrisk/DraftLm22603.pdf*). Copies also were made available in the FSIS Docket Room. Public and peer reviewer comments on the risk assessment and the Agency's response to the comments also can be viewed in the Docket Room and on the Web site.

V. FSIS Risk Assessment of *L. monocytogenes* in RTE Meat and Poultry Products

The FSIS risk assessment and the FDA/FSIS risk ranking on *L. monocytogenes* in RTE foods sold at retail provided a framework for evaluation of, and data on, risk mitigation strategies, including in-plant measures, to inform the Agency in this rulemaking as it considered the need to address potential contamination of RTE products by the pathogen.

FSIS initiated its *Listeria* risk assessment in February 2002 in response to public comments on the proposed rule that suggested the need for a stronger scientific basis for provisions requiring the testing of food contact surfaces for *Listeria* species. The risk assessment was developed: (1) To provide insight into the relationship between *Listeria* species on food contact surfaces and *L. monocytogenes* in RTE meat and poultry products exposed to the environment after the lethality treatment (post-lethality exposure); and (2) to evaluate the effectiveness of food contact surface testing and sanitation regimes, pre- and post-packaging interventions, growth inhibitors, and combinations of these interventions to mitigate contamination of RTE meat and poultry products that are post-lethality exposed, and to reduce the subsequent risk of illness or death from *L. monocytogenes*.

FSIS risk managers asked that the FSIS risk assessors evaluate the effect of various food contact surface testing and sanitation regimes in reducing *L. monocytogenes* contamination of products and the effect of other pre- or post-packaging antimicrobial interventions and of growth inhibitors in reducing such contamination. The risk managers also sought guidance from the risk assessors on testing and sanitation of food contact surfaces for *Listeria* species.

Given the available data and the fact that deli meats comprised about 80 percent of the listeriosis cases associated with ready-to-eat product, the FSIS risk assessment addressed only deli products. In order to evaluate the specific FSIS risk management questions, the risk assessment assumed that all *L. monocytogenes* on RTE product comes from the food contact surfaces and not from inadequate lethality treatment.

Using available data, the FSIS risk assessors developed a dynamic in-plant Monte Carlo simulation model (referred to as the in-plant model) quantitatively characterizing the relationship between *Listeria* species in the in-plant environment and *L. monocytogenes* in a production lot of RTE product at retail.

The outputs of the in-plant model (*e.g.*, concentration of *L. monocytogenes* on deli meats at retail) were used as inputs into the two major components of the FDA/FSIS risk ranking model discussed earlier: the exposure assessment and the associated dose-response relationship for deli meats.

In the FDA/FSIS risk ranking, the retail-to-table exposure assessment for deli meats and the associated dose-response relationship were developed to identify which RTE foods pose the greatest risk for causing listeriosis. Two components of the FDA/FSIS risk ranking model, the exposure assessment for deli meats and the dose-response relationship, were later updated with data and information provided during the public comment period on the draft FDA/FSIS risk ranking. The updated exposure assessment is used to track the level of *L. monocytogenes* in deli meat from retail to table and, using the updated dose-response relationship for *L. monocytogenes*, provides estimates of the subsequent risk of illness or death from consuming deli meats.

The outputs of the FSIS risk assessment model were calibrated to the *L. monocytogenes* concentration in deli meats at retail in the updated FDA/FSIS exposure assessment. That is, the FSIS output data were statistically compared with standard data on *L. monocytogenes* from a reputable third-party to determine whether the output data deviated from the standard data. Calibration of risk assessment models is intended to ensure the accuracy of risk estimates.

By modeling changes in in-plant practices, such as the frequency of testing and sanitation of food contact surfaces, the FSIS risk assessment model provides insight into the effects of these practices on the annual risk of illness or death from *L. monocytogenes* in RTE meat and poultry products. The risk assessment model was designed to provide numerous outputs that depended on the selection of in-plant practices, such as "test and hold," responding after an initial positive food contact surface sample, or alternatively, after consecutive positive samples, and that were based on various plant characteristics (*e.g.*, plant size or production volume).

The most significant findings of the risk assessment model are: (1) The proposed minimal frequency of testing and sanitation of food contact surfaces (66 FR 12589, February 27, 2001) results in a small reduction in the levels of *L. monocytogenes* on deli meats at retail; and (2) combinations of interventions (*e.g.*, sanitation/testing of food contact surfaces, pre- and post-packaging lethality interventions, and growth inhibitors) appear to be much more effective than any single intervention in mitigating the potential contamination of finished RTE products with *L. monocytogenes* and reducing the subsequent risk of illness or death.

Specific model outputs relating to *L. monocytogenes* concentrations in deli products at retail and the resulting public health impacts of various interventions were developed and were presented at a public meeting on February 26, 2003. FSIS accepted comments on its draft risk assessment at the public meeting and afterward, until March 14, 2003 (68 FR 6109; February 6, 2003). The comments received have been included in the record of this rulemaking proceeding. An analysis of comments and responses is available in the FSIS Docket Clerk's Office and on the FSIS Web site at: *http://www.fsis.usda.gov*.

VI. Comments on the Proposal and FSIS Response

On the proposed requirements for controlling *Listeria* in RTE products in the February 27, 2001, **Federal Register** document, FSIS received 28 comments. Comment summaries, grouped by topic, and Agency responses follow.

Support for the Proposal

Comment: Three comments supported the proposed rule and favored even more stringent requirements. They said that manufacturers of RTE products should be required to implement programs for detecting and eliminating *L. monocytogenes* harborages and should perform tests for *L. monocytogenes* and *Listeria* species. All establishments that produce such products should have control programs that include environmental testing. The Agency should require establishments that have CCPs for *L. monocytogenes* to conduct testing. Also, the proposed required sampling frequencies should be increased and the intervals between tests specified. FSIS should mandate specific testing frequencies for product testing to be conducted following an environmental test that is positive for *Listeria*. Two of the commenters suggested that *Listeria* species is an appropriate indicator for *L. monocytogenes*.

The commenters said that FSIS should require even more intensive environmental and product testing than that proposed. Final product testing as well as environmental testing should be required; eventually, continuous product testing should be performed. One commenter opposed the notion of adopting food irradiation as a solution for potential contamination of RTE products.

One commenter said that the Agency should require establishments to test a statistically significant amount of RTE product for *L. monocytogenes*. The establishments also should conduct environmental testing for the organism. If the products are produced by an establishment that does not conduct RTE product testing as part of its HACCP plan, the products should carry warning labels.

Commenters said that FSIS should maintain its "zero tolerance" for *L. monocytogenes* in RTE products rather than setting a minimum colony-forming-unit (CFU) level for the organism in the products, as some have suggested.

A commenter said that official establishments should identify sources of *L. monocytogenes* in their Sanitation SOP.

Response: FSIS agrees with comments that supported establishment use of effective process controls combined with environmental testing to verify the effectiveness of sanitation programs. The Agency also agrees with the comment that establishments should address sources of *L. monocytogenes* either in their HACCP plans or in their Sanitation SOPs or other appropriate procedures. This interim final rule provides a framework within which establishments must meet this objective and provides flexibility for doing so.

FSIS does not agree that it is necessary to mandate *Listeria* testing for establishments that have a CCP for *L. monocytogenes*. Such establishments are already required to validate and verify the CCP's, and microbiological testing is an important means of validation and verification.

FSIS also believes that, if it mandated a high frequency of environmental or product testing, the Agency would be foreclosing unnecessarily the use of effective control programs or strategies adopted by establishments that might require testing at frequencies different from those mandated. In this interim final rule, FSIS is not adopting the proposed frequency requirements. Instead, the Agency is requiring establishments to adopt one of several alternatives that are appropriate for their products and process controls that are effective in addressing *L. monocytogenes*.

On the question of a "zero tolerance" for *L. monocytogenes* and particularly with respect to RTE products that support growth of the pathogen, FSIS currently regards any amount of the organism as a product adulterant. As stated above, because the product is RTE, it is likely to be consumed without any effort to kill the pathogen, and the presence of the pathogen may render the product injurious to health (21 U.S.C. 601(m)(1), 453(g)(1)) and would cause the product to be unhealthful.

General Comments on the Proposal and Its Scientific Basis

Comment: A number of commenters said that the proposed testing requirements are arbitrary, unsupported by the FDA/FSIS risk ranking, and generally unscientific (*i.e.*, they were not based on the relative risk posed by establishments, products, or processes).

Response: FSIS agrees, in principle, that mandating a testing frequency is not well founded. In this interim final rule, FSIS is not adopting the proposed provisions for testing food contact surfaces at specified frequencies. Under the interim final rule, establishments will have to implement effective controls for *L. monocytogenes*. The interim final rule is based on the Agency's conclusion that establishments that process post-lethality exposed RTE products must address *L. monocytogenes* in their food safety systems. Those establishments that rely only on sanitation procedures to control the pathogen should carry out more intensive verification procedures, such as food contact surface testing, to ensure that the procedures are effective, and that products are not contaminated, than establishments that controls the pathogen through their HACCP plans.

Severity of Effects

Comment: In framing the rule, FSIS should consider the relative risk of illness posed by RTE products and the severity of effects.

Response: FSIS has taken into account the relative risk of illness and death posed by the processes and products addressed by this interim final rule as reported in the FDA/FSIS risk ranking of RTE foods sold at retail and the FSIS risk assessment.

Success of Industry Efforts

Comment: The industry has been successful in lowering the incidence of foodborne listeriosis. The industry's efforts will help the country achieve the Department of Health and Human Service's "Healthy People 2010" goals for lowering the incidence of listeriosis in the population within the timeframe established in the May 5, 2000, Presidential directive. Thus, the Agency's proposal to require environmental testing is unjustified, especially in view of the fact that HACCP was intended to obviate the need for this type of prescriptive requirement.

Response: Although it is early to determine whether the "Healthy People 2010" goals for reducing listeriosis (to 0.25 cases per 100,000 population) will be achieved, recent data from CDC indicate that from 1996 to 2002 there was a 38-percent decline in the number of cases per 100,000 population (to .27 overall). Nonetheless, meat and poultry products have been implicated in a substantial proportion (nearly half) of listeriosis cases. FSIS believes that the meat and poultry industry, together with other segments of the food industry, is capable of contributing significantly to the achievement of the Nation's goals for *Listeria* control, particularly by focusing on higher-risk meat and poultry products and on mandatory control procedures—the approach taken in this interim final rule. This interim final rule does not, however, mandate specific testing frequencies.

Effectiveness of Industry Controls

Comment: Some commenters stated that the current HACCP and Sanitation SOP requirements are adequate for ensuring control of *Listeria*. Therefore, the need for regulatory change in this area is questionable.

Response: It is true that validated HACCP plans and effective Sanitation SOPs should be sufficient to address the *Listeria* hazard. The continuing occurrence of product contamination and of significant outbreaks of illness in which meat and poultry products are implicated, however, suggest that establishments have not appropriately addressed the hazard in their HACCP plans, and that the effectiveness of establishment Sanitation SOPs used to control *L. monocytogenes* contamination is not being ensured. The Agency has therefore concluded that it is necessary to require establishments to take specific steps to control the *Listeria* hazard.

Ubiquity of L. monocytogenes and Difficulty of Controlling It

Comment: Several commenters stated that it is important to recognize how ubiquitous *L. monocytogenes* is in the environment and that elimination of *L. monocytogenes* from all food is probably impossible. Thus, the commenters believe, it is not appropriate to require product testing on the basis of a single positive test for *Listeria* spp. on a food contact surface. Some commenters said that environmental testing results should not lead to enforcement actions.

Response: While FSIS does not think that the ubiquity of an organism in the environment argues against regulations requiring control of the organism, the Agency agrees that a more flexible approach to *L. monocytogenes* control than that taken in the proposal is warranted and desirable. FSIS is not adopting the proposed requirement to test product after the first positive test on a food contact surface. Although a positive test for *Listeria* species on a food contact surface does not necessarily mean that product is adulterated, or that enforcement action should be taken, such a finding does suggest the need for corrective action. FSIS inspection program personnel are instructed to verify that the establishment takes the corrective actions it has developed, whether as part of a HACCP plan or of a Sanitation SOP or other prerequisite program.

On the other hand, FSIS regards a positive test for *L. monocytogenes* on a food contact surface as evidencing an insanitary condition that may render product injurious to health. RTE product that comes into contact with the sampled surface at the time it was contaminated with the pathogen and is not subject to any further lethality treatment is adulterated, and FSIS inspection program personnel will take the appropriate action in response to such a finding as set out in Agency directives.

Incentives and Disincentives

Comment: The proposed testing requirements are a disincentive to control *L. monocytogenes* and may actually increase risk of foodborne listeriosis. Establishments might test for the organism at a lower rate than they currently do lest positive tests lead to unwarranted enforcement actions by FSIS. Many small and very small establishments have already implemented *L. monocytogenes* control measures (GMPs, Sanitation SOPs, and testing) in excess of the proposed requirements.

Response: FSIS agrees that mandating testing at a fixed frequency might discourage some establishments that are making strong efforts at *Listeria* control that include regular testing. This recognition factored into the Agency's decision not to adopt the proposed testing frequencies in this interim final rule.

Comment: FSIS should provide incentives for finding harborages, taking corrective actions, and preventing the recurrence of contamination.

Response: FSIS agrees with the comment. When the interim final rule becomes effective, FSIS verification testing will be more intensive in establishments where controls are less rigorous. (*See* discussion of new Directive 10,240.4 below.) Whether FSIS takes an enforcement action will depend on whether establishments are correcting insanitary conditions that may result in product adulteration.

FSIS believes that this interim final rule gives establishments the flexibility to adopt innovative and effective *Listeria* control methods. Moreover, the interim final rule includes a provision enabling establishments to declare on their product labels their use of *Listeria* control measures, provided that the establishments can validate the declarations.

HACCP, Sanitation SOPs, Prerequisite Programs, Directives or Performance Standards

Listeria Controls in HACCP Plans

Comment: Some commenters favored using equipment design, GMPs, and facilities management techniques to control *L. monocytogenes*. They stated that FSIS should recognize that enhanced and focused sanitation and employee behavior programs can be effective preventive and corrective actions. These commenters argued that contamination occurring in a post-lethality processing area is a sanitation, and not a HACCP, issue.

Others argued, to the contrary, that *L. monocytogenes* should be controlled by CCPs in an establishment's HACCP plan.

Response: FSIS is persuaded that *L. monocytogenes* contamination is being prevented in many establishments by Sanitation SOPs and other prerequisite programs. Where these programs are effective, an establishment may conclude in its hazard analysis that *L. monocytogenes* is not a hazard reasonably likely to occur. Of course, in the Agency's view, it is also appropriate to address this hazard in a HACCP plan. Thus, the Agency is allowing establishments the latitude to include *L. monocytogenes* control measures in HACCP plans or to address potential contamination by this pathogen in Sanitation SOPs or other prerequisite programs. It is important to note that if an establishment is applying a post-lethality treatment to an RTE product, the establishment must have concluded that *L. monocytogenes* is a hazard reasonably likely to occur in the product. For this reason, the establishment must include that treatment as a CCP in its HACCP plan.

Comment: Since no technology exists to completely eliminate *L. monocytogenes* from products, a CCP for controlling *L. monocytogenes* is infeasible. Establishments should focus their resources on sanitation and plant improvement projects rather than on HACCP CCPs. Allowing plants to develop CCPs instead of testing, they said, would result in decreased consumer protection.

Response: FSIS disagrees. A CCP in a HACCP plan is a point, step, or procedure in a food process where the occurrence of an identified hazard can be prevented, eliminated, or reduced to an acceptable level. Various methods are available to prevent, eliminate, or reduce *L. monocytogenes* in the RTE products that are subject to this interim final rule and their effectiveness can be validated. For example, a post-lethality heat treatment of a packaged product can eliminate the pathogen. Thus, establishments that use post-lethality treatments for this purpose should include the treatments in their HACCP plans. But establishments may use other methods, including the addition of antimicrobial agents, that have the effect of limiting or suppressing growth of *L.*

monocytogenes in the products. These methods need not be in the establishments' HACCP plans, so long as the plant is regularly ensuring that these methods are working effectively and is making its records that relate to these methods available to FSIS inspection personnel.

Use of Process Controls and Technologies to Control Listeria

Comment: FSIS should encourage establishments to adopt effective process controls, such as food irradiation and high-pressure processing, rather than imposing testing requirements. Relying solely on Sanitation SOPs or GMPs would fail to control *L. monocytogenes*. Further, products that are subject to an in-package lethality treatment before being shipped should be exempt from both environmental and product testing requirements.

Response: FSIS has designed the interim final rule to be sufficiently flexible that establishments will be able to implement a variety of technologies to address *L. monocytogenes*. Of course, before establishments can take advantage of food irradiation for the types of products covered by this interim final rule, FDA approval will be necessary.

FSIS agrees that effective process controls will yield more beneficial results than testing requirements of the kind proposed and that establishments may use various methods to prevent or control *L. monocytogenes* contamination. Therefore, FSIS is not adopting the proposed testing frequency requirements. The Agency is permitting establishments that produce RTE products to implement the type of HACCP or sanitation program that is most appropriate for their production situation and is not imposing uniform testing requirements of the kind proposed. FSIS recognizes that different validation or verification testing regimes are appropriate for different types of products or process control programs, and that a combination of interventions, including post-lethality treatments, sanitation and testing, processing, and the use of growth inhibitors, appears to be most effective in controlling *L. monocytogenes*.

Resource Allocation to Testing or Process Controls

Comment: FSIS has not shown how the proposed, prescriptive, environmental testing will reduce the incidence of *L. monocytogenes* in RTE products. If plants devote resources to environmental testing rather than to effective sanitation activities, consumer protection would decrease. Also, FSIS should let establishments use prerequisite programs instead of CCPs in the HACCP plan to control *L. monocytogenes*.

Response: FSIS acknowledges that testing by itself is insufficient to control *L. monocytogenes* but needs to be a part of a sanitation control program. FSIS regards testing as an essential means of verifying the effectiveness of sanitation procedures to control *L. monocytogenes*, whether the procedures are incorporated in a HACCP plan, a Sanitation SOP, or another prerequisite program. Devoting resources to a testing program developed for this purpose actually supports the control measures.

The proposed *Listeria* testing requirements, which would have mandated specific testing frequencies, were intended for Sanitation SOP verification. Although this interim final rule does not adopt the proposed testing frequency requirements, establishments that do not apply post-lethality treatments to their post-lethality exposed RTE products will have to include at least some food-contact surface testing in their sanitation programs. Such testing is intended to ensure that their measures for controlling, or preventing contamination by, *L. monocytogenes*, whether in HACCP plans or in Sanitation SOPs or other prerequisite programs, are effective.

Comment: FSIS should set a performance standard for *L. monocytogenes* as it has for other pathogens of concern. The Agency should also give establishments the flexibility to meet the standard. Thus, the Agency should consider the problem of pathogen growth after processing and give plants maximum flexibility in testing for *L. monocytogenes*.

Response: FSIS considered the option of adopting a process performance standard for controlling *L. monocytogenes* but determined that there was insufficient scientific information on which to base such a standard. Nonetheless, the Agency has given the establishments flexibility in deciding how to address this pathogen.

FSIS Directive on Microbial Sampling Procedures for RTE Products

Comment: Some commenters said that the Agency should continue to have its personnel use FSIS Directive 10,240.2, which sets out the procedures to be followed when Agency personnel conduct microbiological sampling in establishments that produce RTE products, rather than issuing new regulations. They said that FSIS could revise the Directive and conduct some food contact surface testing, either in all establishments that produce RTE products or just in establishments that do not conduct their own sampling.

Response: FSIS disagrees with the assertion that a regulation is not necessary to ensure effective control of *L. monocytogenes* in RTE products. As noted, with respect to the risk ranking, there is a significant opportunity for recontamination of RTE products in establishments. Many establishments are not implementing HACCP, Sanitation SOPs, or prerequisite programs in a manner that is effective in eliminating *L. monocytogenes* in RTE products. It should also be noted that FSIS replaced its Directive 10,240.2 in December 2002 with a new directive (10,240.3) with updated inspection verification activities. This new directive will be further revised to reflect the requirements of this interim final rule.

Inspection and Enforcement

Comments: FSIS inspectors should be trained to understand *Listeria* testing and the evaluation of the testing results because the considerations involved are complex. FSIS should make compliance guidance materials available for industry review before final regulations take effect.

Response: FSIS will be training its field inspection personnel to ensure that the interim final rule is properly implemented. FSIS's Food Safety Regulatory Essentials training, which addresses RTE products, is being given to all consumer safety inspectors. Regarding guidance materials, FSIS will provide comprehensive guidance to facilitate implementation of this interim final rule by all affected establishments. FSIS will make this guidance material available on its Web site well before this interim final rule takes effect.

Correlation Between Testing and Establishment Size and Production Volume

Comments: There is no evidence that the testing frequencies proposed, which are based on establishment size, will lead to reductions in the rate of listeriosis.

Also, requiring a large establishment to test more frequently than a small one because that establishment manufactured more product is not supportable. The Agency's preliminary economic impact analysis indicated that a small establishment could produce more product than a large establishment because factors other than employees were involved.

Response: FSIS agrees that there is no necessary correspondence between

establishment size and the rate of listeriosis or the degree of risk posed by the products the establishment manufactures. This is one reason why the Agency is not adopting the food contact-surface testing frequencies it proposed. Instead, the Agency is allowing establishments flexibility in designing measures to address *L. monocytogenes*, including appropriate testing and hold-and-test strategies for their products.

FSIS also understands that production volume does not necessarily correspond to establishment size. The Agency has concluded that having better and more comprehensive information about the production volume of RTE products will help it to more efficiently target its resources in verifying establishment *L. monocytogenes* controls.

Hold and Test

Comments: Some commenters stated that requirements for establishments to hold and test product after initial positive tests from environmental sampling would be complicated and likely to result in errors. Such regulation would therefore prove ineffective.

Other commenters insisted that, after an environmental positive, it would be appropriate for an establishment to follow hold-and-test procedures. They said that establishments should regard positive tests for *Listeria* from a non-food contact surface as indicating a sanitation or *Listeria* control problem and that if the positive test were from a food contact surface, all product from the shift represented by the sample should be held and tested before release.

Response: FSIS proposed requirements for food contact-surface testing rather than tests from the general plant environment. In this interim final rule, with the exception of one provision, FSIS is allowing the industry flexibility in designing procedures to be carried out following positive tests for an indicator organism, such as *Listeria* species. However, if a product has been in contact with a food contact surface that has tested positive for *L. monocytogenes*, it is considered adulterated and must be withheld from commerce. FSIS believes that this flexibility should result in the adoption of hold-and-test procedures that are not needlessly complicated and do not result in errors.

Costs and Benefits

Comments: Some commenters stated that the proposed regulations that require establishments to hold and test product after positive environmental test results would impose significant costs that would be especially burdensome to small businesses. Further, it was asserted that establishments unable to hold product because of customer demand or lack of storage facilities would run the risk of incurring the costs associated with increased product recalls.

Commenters argued that FSIS provided little justification for its *Listeria* testing policies in its proposal. They stated that it is difficult to estimate the number of listeriosis cases that might arise from contamination of meat and poultry products and discrepancies in the Agency's proposal illustrated this fact. For example, there is a significant data gap in the relationship between a product contact surface that tests positive for *Listeria*-like, *Listeria* species, and *L. monocytogenes* and whether the product will be positive and the risk to consumers. Commenters suggested that FSIS estimate the reductions in foodborne illness that would result from the regulation and provide further analysis or quantification of costs and benefits.

Response: FSIS agrees that the proposed testing frequency requirements would not be without cost and is interested in ensuring the accuracy of its estimates. To this end, the Agency has accepted data that were submitted by several commenters on this matter and has used the data in preparing the final regulatory impact analysis.

FSIS agrees that the costs associated with product recalls may far exceed those associated with hold-and-test procedures.

On the effect of *Listeria* control regulations on small businesses, FSIS agrees that a relatively large proportion of small establishments will be affected by this interim final rule. FSIS has prepared compliance guidance for such establishments, including guidance specifically intended to assist them in HACCP plan validation with respect to *L. monocytogenes* control, and is making this guidance available with this interim final rule in the FSIS Docket Room and on the Agency's Web site. Also, FSIS will mail the guidance material to all RTE operations before the effective date of this interim final rule.

FSIS agrees with the comments on the difficulties involved in determining the relationship between listeriosis cases and meat and poultry product contamination and with the suggestion that FSIS estimate the reductions in foodborne illness that could result from the regulation. FSIS initiated a risk assessment of in-plant processing of RTE products to determine the relationship between various food contact surface testing and sanitation regimes and other pre- and post-packaging interventions in mitigating contamination of RTE products with *L. monocytogenes* and in reducing the subsequent risk of illness or death and has further analyzed the costs and benefits. FSIS considered the results of the risk assessment in developing this interim final rule. In the final regulatory impact analysis, the Agency analyzes the effect of the interim final rule in terms of the reduction of illness and death from listeriosis.

Definition of RTE and Relative Risk of Different RTE Products

Comments: Commenters expressed concern about the terminology that the Agency used in its proposal. These concerns were related to the scope and effects of the regulation. The commenters said that FSIS should more clearly define RTE products. Some of them stated that frozen products ought not to be considered RTE for the purposes of the rule. To include such products in the RTE category, they argued, would be contrary to previous FSIS policy (Agency directives), the FDA's model food code, and the FDA/FSIS risk ranking model for *Listeria* in RTE foods. The commenters argued that another category of products, dried meat and fermented products, also should not be considered RTE for the purposes of the rule, for their water activity (a_w) puts them at low risk as a medium for growth of *L. monocytogenes*.

The commenters suggested that instead FSIS should define RTE products as "refrigerated foods of extended shelf life (>10 days) that can support the growth of *L. monocytogenes* and that will be consumed without further listericidal treatment." The commenters added that FSIS should base *L. monocytogenes* control requirements on risks posed by specific types of products.

Response: The Agency has revised the definition of RTE to be consistent with the definition of RTE used in the 2001 Food Code. FSIS does not believe that frozen foods, as a broad category, can be excluded from the definition of RTE for this rule. Rather, the Agency will continue to follow its existing practice of determining whether foods should be considered RTE because of the manner of processing and the handling instructions provided to consumers. Some instructions direct that the product must receive further preparation for safety purposes.

Several labeling features or statements are used exclusively on RTE products or non-RTE products, but not on both. RTE products often include phrases indicating that they do not require

further preparation for safety, *i.e.*, "fully cooked," "Ready-to-eat," and "Heat and Serve." Features that are used exclusively on non-RTE products to inform consumers that the products must be cooked to be safe for consumption include the Safe Handling Instructions, which indicate that the meat or poultry portion have not received an adequate lethality treatment and such phrases as, "Raw," "Uncooked," "Not Ready-to-Eat," and "Ready-to-Cook."

Cooking instructions alone, however, are not a reliable labeling feature for consumers to determine whether a product requires cooking for safety. Phrases such as "Cook and Serve," "See cooking instructions," and "Cook thoroughly" have been used interchangeably on both RTE and NRTE meat and poultry products.

FSIS will continue to consider frozen foods that provide clear instructions to consumers about safe handling and cooking requirements as not-RTE and therefore not subject to this regulation. Frozen products that do not meet these requirements will be considered RTE.

The Agency does not agree that either frozen foods or dried meat and fermented products should be excluded from the definition just because they pose a low risk for *L. monocytogenes*. In both cases, the products are lower in risk because they have undergone a process that is either lethal to or suppresses or limits the growth of pathogens, including *L. monocytogenes*. For this reason, FSIS believes that establishments producing these products should also be required to incorporate in their operations measures addressing *L. monocytogenes* to ensure that the products can be consumed safely without further preparation.

Tolerance for L. monocytogenes and Food Safety Objectives (FSO's)

Comments: Some commenters recommended that FSIS establish a tolerance for *L. monocytogenes* in certain products that do not support growth of the organism. The commenters suggested that a FSO would be consistent with the concepts favored by the Codex Alimentarius Commission and the standards applied by some of this Nation's trading partners. A more rigorous standard could be applied to product that is intended for vulnerable populations.

Response: Establishing a tolerance for *L. monocytogenes* is outside the scope of this rulemaking. The Agency is not in a position to set a regulatory tolerance for *L. monocytogenes* in RTE products, for a number of reasons, including the fact that the Agency is unable routinely to identify the end users of the products.

Absent a conclusive demonstration to the contrary, the Agency must regard any amount of *L. monocytogenes* in a RTE product as an adulterant under the FMIA or PPIA (21 U.S.C. 601(m), 453(g)).

Labeling and Consumer Education

Comments: Some commenters said that development of meaningful "use-by" dating that reflects the safety of the product is a practical impossibility. They said that "use-by" dates would only be effective for products that are "refrigerated foods of extended shelf life (>10 days) that can support the growth of *L. monocytogenes* and that will be consumed without further listericidal treatment."

Other commenters maintained that FSIS should require RTE products to have a uniform expiration dating system to identify product that should be frozen or not consumed after a specified number of days. Some commenters said that RTE products should carry warning labels if they are produced by a plant that does not conduct product testing for *L. monocytogenes* as a feature of its HACCP system. Also, they said, because of the possibility that RTE products might be contaminated with *L. monocytogenes*, the products should carry safe-handling labels until testing is required.

Response: FSIS proposed some revisions to the special-handling label requirements that are not addressed in this interim final rule. The Agency did not propose use-by labeling but requested comment on the feasibility of requiring such labeling, including the most effective way to implement it, the assumptions retailers and consumers should be expected to make in using it, scientific and economic data on the shelf-life and safety of RTE meat and poultry products, the kinds of post-lethality interventions that should be expected for products bearing use-by labeling, and the content of the labeling (66 FR 12635). FSIS notes that the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) is currently addressing safety-based use-by dates. FSIS will consider the NACMCF findings and other information of the kind requested in the proposal before any further rulemaking on the issue.

VII. The Interim Final Rule: Control of *L. monocytogenes*

FSIS has considered the information presented in comments on the proposal, public meetings, the FDA/FSIS risk ranking, and the FSIS risk assessment. Given the pathogenicity of *L. monocytogenes*, the opportunity for it to contaminate RTE product in the post-lethality environment, and the significant consequences that this contamination can have, FSIS is amending its regulations. The Agency is adding provisions that require establishments that produce post-lethality exposed RTE product to include in their HACCP plans or in their Sanitation SOPs or other prerequisite programs measures that prevent product adulteration by *L. monocytogenes*.

FSIS is adding several definitions (9 CFR 430.1) to the regulations. FSIS is defining "deli product" and "hotdog product," which are a particular focus of the regulations because of the risks they pose. The Agency is also adding several definitions relating to conditions affecting RTE products after the products have undergone a process that destroys *L. monocytogenes* (9 CFR 430.1).

The first definition in 9 CFR 430.1 is for "antimicrobial agent," which FSIS is defining to mean a substance in or added to an RTE product that has the effect of reducing or eliminating a microorganism or of suppressing or limiting its growth throughout the shelf life of the product. In the context of this regulation, an antimicrobial agent may be added to a post-lethality exposed product (also defined) after its initial lethality treatment. An antimicrobial agent, such as acid from fermentation, may also be an inherent component of the product or a result of its formulation. In any case, the effect of the use of the antimicrobial agent is to limit or suppress growth of *L. monocytogenes*.

"Antimicrobial process" is defined to mean an operation, such as freezing, that is applied to an RTE product and that has the effect of suppressing or limiting the growth of a microorganism. In the context of this regulation, the process is typically applied to a post-lethality exposed product after its initial lethality treatment, and the effect of the process in limiting or suppressing growth of *L. monocytogenes* continues throughout the shelf life of the product. If a product were frozen, the effect of freezing the product could only continue throughout the shelf life of the product if the product were maintained continuously in a frozen state.

The Agency is defining "post-lethality exposed product" as RTE product that comes into direct contact with a food contact surface after undergoing a lethality treatment that is a usual and necessary step in the production of the product, *e.g.*, the cooking step for a hotdog or other cooked sausage. A

definition of "lethality treatment" is provided. The "post-lethality processing environment" is defined as the area of an establishment into which product is routed after undergoing a lethality treatment.

"Post-lethality treatment" is defined as a lethality treatment applied to a product after post-lethality exposure. A post-lethality treatment might be an additional heat step or other pasteurization process, such as high-pressure processing. A "post-lethality treatment" to reduce or eliminate *L. monocytogenes* is to be distinguished from the use of an antimicrobial agent or process that suppresses or limits the growth of the pathogen. Antimicrobial agents include lactic acid in certain types of sausage products or ingredients of growth-limiting packaging (*e.g.*, cellulose containing an antimicrobial substance). An example of a growth suppressing or limiting process is freezing.

FSIS is defining "prerequisite program" as a procedure or set of procedures designed to provide the basic environmental or operating conditions necessary for the production of safe, wholesome food. The definition is adapted from "Hazard Analysis and Critical Control Point Principles and Application Guidelines," which was adopted August 14, 1997, by the National Advisory Committee on Microbiological Criteria for Foods and has wide currency in the food industry. Prerequisite programs are a part of the decision-making documentation that is associated with the hazard identification and selection of CCPs in a HACCP plan. An establishment is required by 9 CFR 417.5 to maintain such documentation because the existence of an effective Sanitation SOP or other prerequisite program affects the outcome of an establishment's hazard analysis.

The definition of a "prerequisite program" is being provided, and the use of such a program in the new regulations is being permitted, in response to industry comments on the proposal emphasizing the importance of prerequisite programs in preventing *L. monocytogenes* contamination. One commenter stated that post-processing contamination by *L. monocytogenes* is best controlled through prerequisite programs.

Finally, FSIS is adopting the definition of a "ready-to-eat" product that, although similar to the one proposed, conforms with the 2001 Model Food Code. Thus, an RTE meat or poultry product is one that is "in a form that is edible without additional preparation to achieve food safety and may receive additional preparation for palatability or aesthetic, epicurean, gastronomic, or culinary purposes."

In a new section on control of *L. monocytogenes* in post-lethality exposed RTE products, 9 CFR 430.4, FSIS first states its basic finding that *L. monocytogenes* is a hazard in such products, and that establishments must control this hazard through their HACCP plans or prevent it in the processing environment through Sanitation SOPs or other prerequisite programs. FSIS is making this finding, as it states in 9 CFR 430.4(a), based on the fact that RTE products that have been subjected to a lethality treatment but then exposed to the environment may be recontaminated with *L. monocytogenes*.

An establishment may determine that recontamination is not reasonably likely to occur in its post-lethality exposed RTE products because it has an effective Sanitation SOP or some other prerequisite program that effectively prevents *L. monocytogenes* contamination. If an establishment makes this determination, under 9 CFR 417.5(a)(2), the regulation requiring establishments to keep documentation supporting the selection of CCPs or critical limits, the basis for this determination must be documented and made available to the Agency. FSIS is aware that, in their hazard analyses, establishments have been taking their Sanitation SOPs and other prerequisite programs into consideration. Thus, an establishment that produces RTE products may not identify *L. monocytogenes* as such a hazard to be addressed in its HACCP plan, it must nonetheless effectively address this pathogen in its food safety system.

The Agency is requiring, in 9 CFR 430.4(b), that an establishment that produces post-lethality exposed RTE product must meet the specific requirements of one of three alternative programs for addressing *L. monocytogenes*. In the view of FSIS, any situation involving establishment measures to address post-lethality contamination of RTE products by *L. monocytogenes* is covered by one of the alternatives. Under this interim final rule, the first alternative relies largely on control though HACCP and an antimicrobial agent or process that suppresses or limits the growth of the pathogen. Each successive alternative places a greater reliance on the rigor of sanitation procedures, including verification testing, than on post-lethality treatments, to control *L. monocytogenes*. Consequently, the frequency and intensity of FSIS verification is likely to be greater for Alternatives 2 and 3, as more reliance is placed on sanitation.

Alternative 1. In the first alternative, an establishment controls *L. monocytogenes* by using a post-lethality treatment of the product *and* an antimicrobial agent or process that suppresses or limits the growth of the pathogen. As mentioned previously, the use of the post-lethality treatment to reduce or eliminate *L. monocytogenes* reflects a determination that the pathogen may be present in the product—in other words, that it is a hazard reasonably likely to occur. Therefore, the establishment must include the post-lethality treatment in its HACCP plan. The point in the process at which the treatment is applied is, by definition, a "critical control point" under 9 CFR 417.1 in that it is a step in a process at which control is applied to prevent, eliminate, or reduce to acceptable levels a food safety hazard, *L. monocytogenes*. The post-lethality treatment incorporated in the HACCP plan must be validated in accordance with 9 CFR 417.4 as being effective in reducing or eliminating *L. monocytogenes*.

The use of an antimicrobial agent or growth suppressing or limiting process may not in practice have the *L. monocytogenes* reduction effect of a post-lethality treatment, but still be an effective measure because it inhibits growth of the pathogen, thus, limiting the possibility that any *L. monocytogenes* that survives the post-lethality treatment will grow out and presents a food safety hazard. In Alternative 1, FSIS is giving the establishment the choice of including the antimicrobial agent or process in its Sanitation SOP or other prerequisite program or as a CCP in its HACCP plan.

FSIS recognizes that an establishment electing to adopt Alternative 1 may employ an antimicrobial agent or process as part of its initial lethality treatment and that the agent or process may have a continuing bactericidal effect on *L. monocytogenes* that persists even through post-lethality exposure and distribution. In such a case, the antimicrobial agent or process could serve as both a post-lethality treatment and growth inhibitor. Thus, neither an additional post-lethality treatment nor an additional antimicrobial agent or process is necessary to qualify for Alternative 1. The establishment would need to have documentation on file to demonstrate that the conditions of Alternative 1 are being met through the application of the initial antimicrobial agent or process.

As with the post-lethality treatment, if the antimicrobial agent or process is

included as a CCP in the HACCP plan, it must be validated as effective in suppressing or limiting growth of the pathogen. The establishment must also verify the effectiveness of the control measures in accordance with 9 CFR 417.4. If the agent or process is included in the establishment's sanitation program, it must be in compliance with the general sanitation regulations and the Sanitation SOP requirements in 9 CFR part 416. The control measures, if included in the HACCP plan, must be validated as effective. The establishment's regular monitoring of its operation must be verified. Sanitation procedures must be in compliance with the general sanitation regulations and the Sanitation SOP requirements, as applicable.

In addition, the establishment is required to make the results of its verification measures, under whichever program—HACCP, Sanitation SOP, or other prerequisite program—available upon request to FSIS inspection personnel.

FSIS has concluded, and this conclusion is informed by the FSIS risk assessment, that Alternative 1, which involves a combination of interventions that includes a post-lethality treatment and the application of an antimicrobial agent or process, is likely to be among the most effective means of reducing the risk of *L. monocytogenes* contamination and hence of listeriosis mortality among vulnerable populations.

Alternative 2. An establishment may choose to address *L. monocytogenes* by using a post-lethality treatment *or* an antimicrobial agent or process that suppresses or limits the growth of the pathogen. As with Alternative 1, the post-lethality treatment, if used, must be included as a CCP in the establishment's HACCP plan. The application of the antimicrobial agent or the growth suppressing or limiting process must be included in the establishment's HACCP plan or in its Sanitation SOP or other prerequisite program. Whichever program includes the application of the antimicrobial agent or the growth suppressing or limiting process, the establishment must have documentation to demonstrate that the antimicrobial agent or process, as used, is effective in suppressing or limiting the growth of *L. monocytogenes.*

In addition, FSIS is providing that if the establishment chooses Alternative 2 and chooses to use only a post-lethality treatment of product, it would likely be subject to more frequent verification testing than if it chose Alternative 1. FSIS has concluded that multiple steps re more likely to reduce the risk of *L. monocytogenes* contamination of RTE products and subsequent adverse public health effects. Without an antimicrobial to suppress or limit the growth of *L. monocytogenes* that may survive the post-lethality treatment, it becomes more important to verify the effectiveness of that treatment.

The establishment may choose not to rely on a post-lethality treatment to reduce or eliminate *L. monocytogenes,* but to use only an antimicrobial agent or process that suppresses or limits the growth of *L. monocytogenes.* If so, it becomes extremely important to minimize any possibility of post-lethality contamination. The establishment's sanitation program must, therefore, provide for the testing of food contact surfaces in the post-lethality processing environment to ensure that the establishment's sanitation program is effective in keeping those surfaces sanitary and free of *L. monocytogenes* or of indicator organisms that would reflect the presence of *L. monocytogenes.* The program must delineate the frequency with which testing will be done, state the size and location of the sample sites (so that the area represented by a sample can be known), and provide an explanation of why the testing frequency is sufficient to ensure that effective control of *L. monocytogenes* or the indicator organism is being maintained. The program also must identify the conditions under which the establishment will implement hold-and-test procedures after a positive test for *L. monocytogenes* or indicator organisms.

As under the Alternative 1, the establishment must make the verification results of the effectiveness of its controls from its HACCP, Sanitation SOP, or other prerequisite program available upon request to FSIS inspection personnel.

For Alternative 2, if the measures for addressing *L. monocytogenes* are in a prerequisite program other than a Sanitation SOP, the establishment must ensure that the program is effective and does not cause the hazard analysis or the HACCP plan to be inadequate. The establishment's documentation of its program and of its results and its implementation of the program must be sufficient to support a finding, during validation or reassessment, under 9 CFR 417.4, that the HACCP plan is adequate and that the HACCP plan in operation is not inadequate within the meaning of 9 CFR 417.

Alternative 3. An establishment that processes RTE products may control *L. monocytogenes* in the post-lethality processing environment through sanitation procedures only. If incorporated in the HACCP plan, the sanitation procedures followed in this alternative must be validated and verified in accordance with 9 CFR 417.4. Also, sanitation in the post-lethality processing area must be maintained in accordance with 9 CFR 416.

As in Alternative 2, FSIS is requiring that the sanitation procedures in the post-lethality processing environment include testing of food contact surfaces to ensure that the surfaces are sanitary and free of *L. monocytogenes* or an indicator organism. The procedures must delineate the frequency of testing; state the size and location of sample sites; and provide an explanation of why the testing is sufficient to ensure that the establishment's sanitation procedures are effectively keeping *L. monocytogenes* or indicator organisms from contaminating product. The establishment must identify in its procedures the conditions under which it will implement hold-and-test procedures to ensure that *L. monocytogenes* or indicator organisms are not contaminating product.

Establishments that adopt Alternative 3 will need to address in their decisionmaking documents why the sanitation procedures they employ, the frequency of testing they carry out, and the circumstances in which they test the product and hold it pending receipt of test results are appropriate and adequate to prevent the contamination of their product by *L. monocytogenes* and to ensure that contamination is discovered if it has occurred.

Because establishments using Alternative 3 are relying only on sanitation procedures and because verification activities are so important to ensuring the on-going effectiveness of such measures, FSIS has concluded that establishments electing to adopt Alternative 3 are likely to be subject to a higher frequency of testing by FSIS than establishments using Alternative 1 or 2. As is the case with establishments adopting the other alternatives, an establishment that has adopted Alternative 3 must make the verification results obtained from its own food contact surface testing available on request to FSIS inspection personnel.

Under Alternative 3, more stringent requirements apply to an establishment that processes deli meats or hotdogs. These products were shown in the FDA/FSIS risk ranking to pose a relatively high risk of listeriosis, in terms of cases per annum. Thus, in order to provide the assurance that comes from increased verification, FSIS expects the frequency of its own testing, as well as the establishment's testing, to be higher

than that for other products produced under the Alternative 3 approach.

Under Alternative 3, for establishments producing deli meats and hotdogs, FSIS is requiring specific procedures for holding and testing product to minimize the risk of contaminated product entering commerce. These procedures are to be followed if an establishment has had a positive test for an indicator organism, such as *Listeria* species, on a food contact surface in the post-lethality processing environment.

After the establishment takes corrective action to clean the food contact surface, the establishment must verify that the corrective action has been effective through follow-up testing in the post-lethality processing area. This testing is to include targeting the specific site on the food contact surface area that was the most likely source of contamination by the organism and must include such additional tests of the surrounding food contact surface area as are necessary to ensure the effectiveness of the corrective action. (If the initial positive test was for *L. monocytogenes*, the product is considered adulterated and must be withheld from commerce even before the results of further testing are available.)

If, during this follow-up testing, the establishment obtains a second positive test result for the indicator organism on a sample from the previously tested area, the establishment must hold lots of product produced between the second positive test result and completion of the corrective action until samples from the food contact surfaces in the same area test negative for *L. monocytogenes* or the indicator organism. The establishment may sample and test the held product, using a sampling method that will provide a level of statistical confidence that is sufficient to establish that the product is not adulterated with *L. monocytogenes*, and it can release the product into commerce if the results are negative.

For Alternative 3, if the measures for addressing *L. monocytogenes* are in a prerequisite program other than a Sanitation SOP, the establishment must ensure that the program is effective and does not cause the hazard analysis or the HACCP plan to be inadequate. The establishment's documentation of its program and of its results and its implementation of the program must be sufficient to support a finding, during validation or reassessment, under 9 CFR 417.4, that the HACCP plan is adequate and that the HACCP plan in operation is not inadequate within the meaning of 9 CFR 417 part 1.

Estimates of annual production volume. As previously stated in this document, some commenters observed that a large establishment may not necessarily produce more RTE product than a small establishment. FSIS agrees and regards production volume as a more important risk factor than establishment size. FSIS intends to target its inspection resources on the higher volume operations. To do this effectively, FSIS will need data on the annual production volume of post-lethality exposed RTE products produced, by product, and by *L. monocytogenes* control alternative (1, 2, or 3), and other related information (such as the establishment's own testing procedures). The affected establishments will have to provide FSIS with this information at least annually. The Agency expects to have an electronic form available for this purpose (9 CFR 430.4(f)).

Labeling Incentive

Finally, FSIS is allowing establishments that use post-lethality treatments or antimicrobial agents or processes that are effective in destroying *L. monocytogenes* or in limiting its growth to declare this fact on the labels of their products. The purpose of the labeling is to inform consumers about measures that have been taken to ensure the safety of the products and thus to enable the consumers to select such products in preference to others. This provision is entirely voluntary, but FSIS believes that labeling claims about treatments that eliminate, suppress, or limit the growth of *L. monocytogenes* can be of value to consumers, especially those in groups most vulnerable to foodborne infection.

For example, products with antimicrobial agents can be viewed as containing substances that reduce the presence of pathogens or the likelihood of foodborne illness, provided that the products are appropriately handled throughout the distribution chain and prepared safely by the consumer. Thus, a label statement should identify the presence of ingredients and their purpose of use but not claim that the product is somehow "safer than" other untreated products.

Examples of statements that can be made are: "Sprayed with a solution of sodium lactate to prevent the growth of *L. monocytogenes*" or "Contains sodium diacetate and sodium lactate to prevent the growth of *Listeria monocytogenes*."

New and Existing Regulatory Requirements

The regulations promulgated in this interim final rule include new requirements and reiterate for clarity certain existing regulations. The definitions in § 430.1 are new, as are the provisions in § 430.4 specifying the three permissible alternatives for addressing *L. monocytogenes*. Similarly, the provisions in this interim final rule requiring that measures included in the establishment's Sanitation SOP or other prerequisite program are new. The provision requiring that RTE establishments report at least annually the volume of production by type of RTE product and by alternative for controlling or addressing *L. monocytogenes* is new. Also new are the sanitation procedure requirements that include hold-and-test provisions.

Although the use by industry and the Agency's acceptance of prerequisite programs is not new, the provisions on prerequisite programs in this interim final rule constitute explicit recognition, for the first time in the codified regulations, of such programs. The requirement that documentation of prerequisite programs and the results of such programs be available to the Agency also makes explicit an implied requirement in the HACCP regulations.

Also, the requirement that a post-lethality treatment be included in an establishment's HACCP plan is made explicit for the first time in this interim final rule. The requirement to maintain documentation on Sanitation SOPs or other prerequisite programs that are used to support a decision not to identify *L. monocytogenes* as a hazard reasonably likely to occur that must be controlled makes explicit a requirement in the HACCP regulations (9 CFR 417.5). The provision for validation of controls included in a HACCP plan just reiterates existing requirements of 9 CFR 417.4. Similarly, the requirement that Sanitation SOPs be evaluated routinely to ensure their effectiveness reiterates the requirements in 9 CFR 416.14.

The requirement to verify, that is, to evaluate routinely and maintain, the effectiveness of the Sanitation SOP, is already a regulation (at 9 CFR 416.14). Also, the requirement to follow existing sanitation requirements in the post-lethality processing environment simply reiterates the general sanitation regulations (9 CFR 416) that are applicable everywhere in an official establishment.

Finally, the provision for RTE product labeling that declares the fact of an *L. monocytogenes* control treatment or ingredient is new, but permissive. RTE product labeling may, under current regulations, bear such statements if the statements are valid.

VIII. Implementation

Implementation Strategy

FSIS has designed this interim final rule to recognize that there are alternative, effective ways to ensure that post-lethality exposed RTE products do not become contaminated with *L. monocytogenes*. While each approach can be effective in preventing such contamination, Alternatives 1 and 2 present a greater opportunity for mitigating the risk of RTE product contamination than does Alternative 3 because under Alternatives 1 and 2, products are formulated or processed in a manner either to eliminate *L. monocytogenes* or to limit its growth, should it be present.

Hence, in implementing this interim final rule, FSIS plans to conduct verification activities, including testing, that focus most intensively on Alternative 3 establishments and, within that group, on establishments that produce deli meats and hotdogs to verify that the total food safety system under which these products are produced is working properly.

FSIS is aware that the regulated industry is using antimicrobial agents at levels that provide some limitation of growth, that some establishments use these agents at levels that allow no more than 2-$\log_{10}$ growth throughout the shelf-life of the product, and that other establishments are using the agents at levels that more severely limit growth. FSIS believes that the majority of products formulated with the higher levels of antimicrobial agents are cured products because they better tolerate the agents, and the products do not have unacceptable organoleptic qualities. For this reason, the FSIS verification testing program for Alternative 2 will cover establishments that produce products formulated with antimicrobial agents but will focus on establishments using lower levels of antimicrobial agents because there is some potential for pathogen growth in the products. However, FSIS does not intend to conduct its verification testing at such establishments at a rate that is any higher than that for establishments in Alternative 3 and certainly not at a rate as high as that for establishments using Alternative 3 and producing deli meats or hotdogs.

FSIS intends to collect information about the RTE products produced by establishments using Alternatives 1 through 3. The information will include estimates of production volume for post-lethality exposed products, so that the Agency can develop annual sampling frequencies for the establishments and the products. FSIS will make the sampling frequency information available to the establishments so that they will have some indication of how the risk of *L. monocytogenes* contamination is tied to FSIS verification testing.

FSIS is continuing to model scenarios in its risk assessment model and will use this information in determining where to direct its verification testing resources to ensure that such products are not adulterated. In the meantime, FSIS will continue to use currently available production volume figures in directing these resources.

The Agency expects to weight its sample scheduling process so that a large-volume establishment will be targeted more frequently than an establishment with a lower volume of production. Because, under this interim final rule, all establishments must have written programs that address *Listeria* and share their testing results with FSIS, FSIS believes that there will be no need to phase in the implementation of the interim final rule for establishments of different sizes or of different production volume capacity. The effective date will be October 6, 2003, for all establishments. During the 120 days before the interim final rule becomes effective, FSIS will issue a new directive (Directive 10,240.4, discussed below). The Agency is now making available new compliance guidelines that will contain information about the effects of sanitation and testing, as well as the effectiveness of various levels of antimicrobials.

New Directive for FSIS Inspection Program Employees

Through a new directive replacing FSIS Directive 10,240.3 that issued in December 2002, FSIS will conduct a risk-based verification testing program to assess the effectiveness of RTE operations in controlling *L. monocytogenes*. FSIS will identify the general features of the design of its verification testing program. Each fiscal year, FSIS identifies the general number of samples that it expects to collect throughout the year associated with RTE products. In order to implement this interim final rule, FSIS expects to apportion the types of products sampled with an emphasis on deli meats and hotdogs produced under Alternative 3. All RTE products are subject to being tested.

Until FSIS has actual production volume and associated data obtained through the reports required by 9 CFR 430.4(f), FSIS likely will continue sampling in the same manner currently employed by the Agency. FSIS intends to build in the production volume feature, as soon as possible, in order to ensure that larger volume production is verified more frequently than smaller volume production. In addition, FSIS will continue to assess information about sanitation non-compliances and other plant performance indicators when determining which operations should be tested, but with an emphasis on products that allow for growth of *L. monocytogenes*.

As FSIS obtains information on the effectiveness of establishment process controls for *L. monocytogenes*, the Agency should be able to reduce the intensiveness of verification testing at establishments with more effective controls.

Generally, FSIS expects to collect for *L. monocytogenes* testing just one sample unit of RTE product from a production lot at an establishment selected for sampling. FSIS is considering taking more than one product sample from an establishment that produces product without post-lethality treatments or growth inhibitors, particularly deli meat and hotdog operations. Finally, FSIS expects to collect food contact surface samples and environmental samples mainly from operations that have a history of problems associated with the proper control for *L. monocytogenes*, or that produce RTE products, particularly deli meats and hotdogs, that allow for the growth of *L. monocytogenes*.

IX. Consumer Outreach Effort

Food safety education is one risk management strategy FSIS uses to reduce the incidence of illness associated with *L. monocytogenes* in RTE meat and poultry products. Safe handling, storage and preparation of RTE meat and poultry products can help reduce the risk of illness, particularly for those populations most at risk of contracting listeriosis: pregnant women, newborns, older adults, people with weakened immune systems caused by cancer treatment, AIDS, diabetes, kidney disease, and organ transplants. FSIS reaches these audiences through printed materials, the FSIS Web site, electronic communication, the media, and other information multipliers, in collaboration with other Federal agencies, educators, and healthcare professionals, and through the USDA Meat and Poultry Hotline.

For example, FSIS has worked with the Association of Women's Health, Obstetric and Neonatal Nurses, the International Food Information Council Foundation, FDA, and CDC to produce a patient education sheet, "Listeriosis and Pregnancy: What is Your Risk?" targeted to both pregnant women and

their healthcare providers. The Spanish version will be printed in spring 2003. In addition, FSIS is completing a low literacy flyer aimed at pregnant women entitled, "Protect Your Baby and Yourself from Listeriosis" with input from WIC nutritionists, public health nurses, and extension food safety specialists. To reach other vulnerable groups, discussions are underway with transplant organizations, community health clinics, geriatric organizations, dialysis centers, and AIDS/HIV care organizations to determine how best to reach these individuals. Through the newly launched Food Safety Education Mobile, informational materials will be distributed as the vehicle travels throughout the country.

In addition to providing education on safe food handling, FSIS will provide information to consumers regarding new labels that processors may voluntarily use under this regulation to inform consumers of interventions used to reduce contamination.

X. Executive Order 12866 and Effect on Small Entities

This interim final rule has been reviewed by the Office of Management and Budget under E.O. 12866 and has been determined to be economically significant. FSIS is amending the Federal meat and poultry inspection regulations by adding requirements for establishments that produce certain RTE meat and poultry products to take measures to prevent product adulteration by the pathogen *L. monocytogenes*. Establishments that produce RTE meat and poultry products that are exposed to the environment after lethality treatments must include in their HACCP plans or their Sanitation SOPs or other prerequisite programs measures designed to prevent product adulteration by *L. monocytogenes*. The establishments also must share with FSIS all data relevant to the validation, operation, and verification of their controls for *L. monocytogenes*.

This action is compelled by outbreaks of foodborne illness in which RTE meat and poultry products contaminated with *L. monocytogenes* were implicated, coupled with information on the pathogenicity of the organism and the findings of the risk assessment and risk ranking conducted by FDA and FSIS. Although FSIS now routinely conducts food contact surface and environmental sampling in select establishments that produce such products, and performs product testing in nearly all RTE establishments for the presence of this pathogen before the products are distributed, until now there have been no specific regulatory requirements for controlling the pathogen. Appendix A, published at the end of this interim final rule in this issue of the **Federal Register**, contains the final regulatory analysis required by E.O. 12866 and the Regulatory Flexibility Act (at 5 U.S.C. 604), including a discussion of the need for the regulations, regulatory alternatives considered by FSIS, and a cost-benefit analysis. This interim final rule provides affected small and very small establishments with the flexibility to minimize the costs associated with this rule by implementing Sanitation SOPs or other prerequisite programs. FSIS is providing compliance guidance for these establishments in accordance with the Small Business Regulatory Enforcement Fairness Act. In addition, in verifying compliance with this interim final rule, the Agency plans to conduct testing at modulated frequencies, taking into account all relevant factors, including the alternative employed to address *L. monocytogenes*, production volume by type of RTE product produced, and the establishment's compliance history.

Summary of Final Regulatory Impact Analysis (FRIA)

Benefits

FSIS has estimated the benefits of this interim final rule in terms of averted deaths and illnesses resulting from actions taken by establishments that produce RTE meat and poultry products so far with respect to only one product group: Deli meats. FSIS has concentrated on this product group for several reasons: The FDA/FSIS risk ranking identified deli meats as posing the most overall risk to public health. The FSIS in-plant risk assessment tied risk mitigation actions to possible reductions in deaths and illnesses from listeriosis when the FSIS risk assessment model was calibrated with the FDA/FSIS risk ranking model, and when containment strategies for *Listeria* contamination of RTE meat and poultry products were simulated. The FSIS risk assessment model has been presented to the public, along with estimates of reduced listeriosis mortality resulting from actions taken by establishments that prepare or process the products.

The FRIA relies on results from the FSIS in-plant risk assessment model and considers the adoption by large, small, and very small deli-meat producing establishments of stratagems of varying rigor for controlling *L. monocytogenes*. The analysis shows that adoption of *L. monocytogenes* mitigation measures induced by this interim final rule results in a total median reduction of deaths from listeriosis of 27.3; with 8.9 deaths averted at the 5th percentile and 31.2 at the 95th percentile. These gains are attributable to an expected shift—discussed in detail in Appendix A—of establishments from sanitation-only to "Alternative 1" and "Alternative 2" methods of addressing *L. monocytogenes*. The corresponding reductions in illnesses are 136.7 at the median, with 44.6 at the 5th percentile, and 156.0 at the 95th percentile.

Using a method used by USDA's Economic Research Service (ERS) for estimating the human health benefits of reduced listeriosis, the benefits of the reduction in illness-related losses due to the interim final rule are estimated to be $3.7 million at the median ((.05 x 136.7 x $10,300) + (.95 x 136.7 x $28,300)) and $1.3 million at the 5th and $4.4 million at the 95th percentile.

ERS estimated the value of statistical life at $4.8 million [7] as a proxy for the cost of one fatality. Based on this estimate, the annual human health benefits from implementation of the interim final rule are $134.9 million at the median (the $3.7 million above plus 27.3 × $4.8 million) and $44.0 million at the 5th percentile and $154.0 million at the 95th percentile.

Given the limitations in data and the fact that the risk assessment addresses only deli meats, FSIS believes that this estimate may be overstated by at least 50 percent. If so, the adjusted annual net benefits then become $50.8 million at the median, $5.4 million at the 5th percentile, and $60.4 million at the 95th percentile. FSIS performed a sensitivity analysis on the benefits estimates. Given the cost estimates, the total benefits of this rule would have to be 85 percent lower than estimated for the net benefits to lower to zero.

Cost Impacts

FSIS estimated the cost impacts of this interim final rule on all affected establishments. The FRIA adds several cost impacts in addition to those considered in the preliminary regulatory impact analysis (PRIA). The PRIA identified major cost impacts from mandatory food contact surface testing, HACCP plan modification, and production adjustments. In addition to these and in response to comments, the FRIA considers the costs, both fixed and recurring, associated with the installation by establishments of post-lethality treatments; the costs, both fixed and recurring, associated with product formulation or process changes to include antimicrobial agents or processes that limit the growth of *L. monocytogenes*; and the costs to establishments required to hold and test products pending confirmation of

positive food contact-surface tests for *Listeria* species.

FSIS estimates that the interim final rule will have combined one-time and recurring costs to large establishments totaling about $15.9 million, to small establishments about $55.3 million, and to very small establishments about $1.7 million. FSIS assumes a 10-year useful life for the changes (*e.g.*, post-lethality treatment validation, installation, antimicrobial agent or process alteration, and production adjustments) for which establishments incur one-time costs and, using a 7-percent discount rate, the Agency annualizes these one-time costs over the useful life of the changes. Adding these to the annual recurring costs, FSIS obtains annualized industry-wide costs of the interim final rule to large establishments of about $3.6 million, to small establishments about $12.5 million, and to very small establishments about $613,000.

The grand total of industry-wide annualized costs is $16.6 million. With the 50 percent downward adjustment discussed above, net benefits of $50.8 million at the median and ranging from $5.4 million at the 5th percentile to $60.4 million at the 95th percentile are to be derived from the interim final rule.

Paperwork Reduction Act

FSIS has reviewed the paperwork and recordkeeping requirements in this interim final rule in accordance with the Paperwork Reduction Act and has determined that the paperwork requirements respecting the regulations that may cause establishments to evaluate and revise their Sanitations SOPS, HACCP plans, and prerequisite programs have already been accounted for in the Pathogen Reduction/Hazard Analysis and Critical Control Point (HACCP) Systems information collection approved by the Office of Management and Budget (OMB). The OMB approval number for the Pathogen Reduction/Hazard Analysis and Critical Control Point (HACCP) Systems information collection is 0583–0103.

The requirement that may cause establishments to test for *L. monocytogenes*, to document their testing protocols and their hold-and-test procedures, and the requirement for establishments that produce RTE products to provide FSIS with production volume information by product type and *L. monocytogenes* control alternative are new information collections.

Title: Listeria.

Type of Collection: New.

The paperwork and recordkeeping requirements in this interim final rule are awaiting approval by the Office of Management and Budget.

Abstract: FSIS has reviewed the paperwork and recordkeeping requirements in this interim final rule in accordance with the Paperwork Reduction Act. Under this interim final rule, FSIS is requiring an information collection activity. FSIS is requiring that establishments that produce ready to eat product annually report the estimated production volume by product type and *Listeria* control alternative employed. FSIS is also publishing requirements for RTE establishments to conduct, and plans to ask them to report on, food-contact surface sampling. In addition, FSIS is establishing requirements that may cause some RTE establishments to hold and test product for *L. monocytogenes* and other indicator organisms.

Estimate of Burden: FSIS estimates that the time to collect and report the required information on the estimated volume of RTE product by product type and *Listeria* control method is one hour. The Agency estimates that it will take establishments 50 minutes to collect the information necessary to make the required estimates and 10 minutes to report the information by form.

FSIS estimates that it will take 25 hours to develop a microbiological sampling and testing plan to support the efficacy of the sanitation controls, including the development of test-and-hold procedures. The Agency estimates that it will take two hours to revise microbiological sampling and testing plans. And FSIS estimates that it will take an average of 30 minutes to conduct a food contact surface test and an average of 30 minutes to collect information on product samples for test and hold procedures.

Respondents: Meat and poultry product establishments that produce Ready to Eat product.

Estimated Number of Respondents: 4,975.

Estimated Number of Responses per Respondent: 10.

Estimated Total Annual Burden on Respondents: 154,243 hours.

Copies of this information collection assessment can be obtained from John O'Connell, Paperwork Reduction Act Coordinator, Food Safety and Inspection Service, USDA, 112 Annex, 300 12th Street, SW., Washington DC 20250.

Comments are invited on: (a) Whether the proposed collection of information is necessary for the proper performance of FSIS' functions, including whether the information will have practical utility; (b) the accuracy of FSIS' estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used; (c) ways to enhance the quality, utility, and clarity of the information to be collected; ways to minimize the burden of the collection of information on those who are to respond, including through the use of appropriate automated, electronic, mechanical, or other technological collection techniques, or other forms of information technology. Comments may be sent to both John O'Connell, Paperwork Reduction Act Coordinator, at the address provided above, and the Desk Officer for Agriculture, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20253.

All responses to this notice will be summarized and included in the request for OMB approval. All comments will also become a matter of public record.

Government Paperwork Elimination Act (GPEA)

FSIS is committed to achieving the goals of the GPEA, which requires Government agencies, in general, to provide the public with the option of submitting information or transacting business electronically to the maximum possible extent. FSIS is making available to establishments affected by this interim final rule an electronic form by which they may provide the required production volume information. The form will be accessible on a special page on the FSIS Web site at *http://www.fsis.usda.gov*; log-on and authentication instructions will be provided. Each establishment's submission will be treated as confidential. Provision of this electronic form is expected to enable the Agency more efficiently to gather, and affected establishments to report, the needed information.

This electronic data collection is intended to meet Goal 4 of the e-Government strategy in the President's Management Agenda. The electronic filing option is provided to reduce data collection time and information processing and handling for the regulated industry and FSIS.

This electronic data collection is intended to be consistent with Goal 2 (enhancing collaboration with public and private sector organizations to develop and deliver USDA's mission) and Objective 2.4 of the Department's e-Government Strategic Plan in that it reduces time necessary for information collection and processing for both regulated establishments and FSIS. A further, related initiative, providing for use of electronic signatures and authentication, will be consistent with the Department-wide strategies and

policies to develop and implement e-signature and e-Authentication policies.

1. The interim final rule on *L. monocytogenes* control in ready-to-eat meat and poultry products contains a requirement for official establishments that prepare post-lethality exposed ready-to-eat meat and poultry products to provide FSIS at least annually with data on the volume of production of products they prepare in processes that are covered by the interim final rule. FSIS is developing a form by which to collect the data. The form will be made available to establishments in both paper and electronic formats. The electronic form will be available for use by affected establishments at all times after the rule becomes effective.

2. FSIS can use its existing information technology resources in the electronic data collection. That is, the Agency plans to use its existing database applications and server storage to house the data collection form and associated databases. FSIS estimates that no more than $1,000 in materials and 0.25 FTE annually at the level of a GS–13 or equivalent staff officer grade in FSIS'S Data Analysis Systems and Support Staff, Office of Policy and Program Development, will be required to administer the data collection.

FSIS is developing a centralized system known as the FSIS Automated Corporate Technology Suite (FACTS) for which approximately $15 million has been earmarked. The system will provide, among other things, facilities for accessing Agency electronic forms and for processing the data collected through such forms. The new production volume form can be integrated with FACTS.

3. FSIS plans to use e-signature and e-Authentication methods that are consistent with Department e-Authentication policy.

4. Regarding information security, FSIS plans to provide ordinary levels of protection for the production volume information obtained. Establishment-linked information will be treated as confidential and stored in password-protected databases and electronic systems to which only authorized personnel have access. Information in paper format will be stored under lock and key in file boxes or cabinets to which only authorized personnel have access. FSIS does not envision a need for sophisticated security or encryption systems to protect this information.

5. For the purpose of this information collection, FSIS does not foresee a need for telecommunications systems additional to those already operated by the Agency.

6. The interim final rule does not specifically address recordkeeping by establishments but only data reporting. The data collected will be stored in a protected database managed by FSIS.

XII. E. O. 12988 Civil Justice Reform

This interim final rule has been reviewed under Executive Order 12988, Civil Justice Reform. States and local jursidicitons are preempted by the FMIA and the PPIA from imposing any marking, labeling, packaging, or ingredient requirements on federally inspected meat and poultry products that are in addition to, or different than, those imposed under the FMIA or PPIA. States and local jurisdictions may, however, exercise concurrent jurisdiction over meat and poultry products that are outside official establishments for the purpose of preventing the distribution of meat and poultry products that are misbranded or adulterated under the FMIA or PPIA, or, in the case of imported articles, that are not at such an establishment, after their entry into the United States. This proposed rule is not intended to have retroactive effect.

Administrative proceedings will not be required before parties may file suit in court challenging this interim final rule. However, the administrative procedures specified in 9 CFR 306.6 and 381.35 must be exhausted before any judicial challenge of the application of the provisions of this interim final rule, if the challenge involves any decision of an FSIS employee relating to inspection services provided under the FMIA or PPIA.

XIII. Additional Public Notification

Public awareness of all segments of policy development is important. Consequently, in an effort to better ensure that minorities, women, and persons with disabilities are aware of this interim final rule, FSIS will announce it and provide copies of this **Federal Register** publication in the FSIS Constituent Update.

The Constituent Update provides information on FSIS policies, procedures, regulations, **Federal Register** notices, FSIS public meetings, recalls, and any other types of information that could affect or would be of interest to our constituents/stakeholders. These include industry, trade, and farm groups, consumer interest groups, allied health professionals, scientific professionals, and other individuals that have requested to be included. The Constituent Update is available on-line through the FSIS Web page located at *http://www.fsis.usda.gov/OA/update/update.htm.*

The FSIS Constituent Update is issued via the USDA-FSISConstituentsListserv to over 400 organizations and individuals on a weekly basis. FSIS also issues other communications on the Listserv, including news releases, recall notices, and Constituent Alerts on important issues. Persons interested in subscribing to the Listserv can do so by completing a form at *http://www.fsis.usda.gov/OA/update/subscribe.asp.*

XIV. Final Regulations

List of Subjects in 9 CFR Part 430

Food labeling, Meat inspection, Poultry and poultry products inspection.

■ Accordingly, title 9, chapter III, of the Code of Federal Regulations is amended as follows:

■ 1. A new part 430 is added to read as follows:

PART 430—REQUIREMENTS FOR SPECIFIC CLASSES OF PRODUCT

Sec.
430.1 Definitions.
430.4 Control of Listeria monocytogenes in post-lethality exposed ready-to-eat products.

Authority: 7 U.S.C. 450; 7 U.S.C. 1901–1906; 21 U.S.C. 451–470, 601–695; 7 CFR 2.18, 2.53.

§ 430.1 Definitions.

Antimicrobial agent. A substance in or added to an RTE product that has the effect of reducing or eliminating a microorganism, including a pathogen such as *L. monocytogenes,* or that has the effect of suppressing or limiting growth of *L. monocytogenes* in the product throughout the shelf life of the product. Examples of antimicrobial agents added to RTE products are potassium lactate and sodium diacetate.

Antimicrobial process. An operation, such as freezing, applied to an RTE product that has the effect of suppressing or limiting the growth of a microorganism, such as *L. monocytogenes,* in the product throughout the shelf life of the product.

Deli product. A ready-to-eat meat or poultry product that typically is sliced, either in an official establishment or after distribution from an official establishment, and typically is assembled in a sandwich for consumption.

Hotdog product. A ready-to-eat meat or poultry frank, frankfurter, or wiener, such as a product defined in 9 CFR 319.180 and 319.181.

Lethality treatment. A process, including the application of an

antimicrobial agent, that eliminates or reduces the number of pathogenic microorganisms on or in a product to make the product safe for human consumption. Examples of lethality treatments are cooking or the application of an antimicrobial agent or process that eliminates or reduces pathogenic microorganisms.

Post-lethality exposed product. Ready-to-eat product that comes into direct contact with a food contact surface after the lethality treatment in a post-lethality processing environment.

Post-lethality processing environment. The area of an establishment into which product is routed after having been subjected to an initial lethality treatment. The product may be exposed to the environment in this area as a result of slicing, peeling, re-bagging, cooling semi-permeable encased product with a brine solution, or other procedures.

Post-lethality treatment. A lethality treatment that is applied or is effective after post-lethality exposure. It is applied to the final product or sealed package of product in order to reduce or eliminate the level of pathogens resulting from contamination from post-lethality exposure.

Prerequisite program. A procedure or set of procedures that is designed to provide basic environmental or operating conditions necessary for the production of safe, wholesome food. It is called "prerequisite" because it is considered by scientific experts to be prerequisite to a HACCP plan.

Ready-to-eat (RTE) product. A meat or poultry product that is in a form that is edible without additional preparation to achieve food safety and may receive additional preparation for palatability or aesthetic, epicurean, gastronomic, or culinary purposes. RTE product is not required to bear a safe-handling instruction (as required for non-RTE products by 9 CFR 317.2(l) and 381.125(b)) or other labeling that directs that the product must be cooked or otherwise treated for safety, and can include frozen meat and poultry products.

§ 430.4 Control of Listeria monocytogenes in post-lethality exposed ready-to-eat products.

(a) *Listeria monocytogenes* can contaminate RTE products that are exposed to the environment after they have undergone a lethality treatment. *L. monocytogenes* is a hazard that an establishment producing post-lethality exposed RTE products must control through its HACCP plan or prevent in the processing environment through a Sanitation SOP or other prerequisite program. RTE product is adulterated if it contains *L. monocytogenes* or if it comes into direct contact with a food contact surface which is contaminated with *L. monocytogenes*.

(b) In order to maintain the sanitary conditions necessary to meet this requirement, an establishment producing post-lethality exposed RTE product must comply with the requirements included in one of the three following alternatives:

(1) *Alternative 1.* Use of a post-lethality treatment (which may be an antimicrobial agent) that reduces or eliminates microorganisms on the product *and* an antimicrobial agent or process that suppresses or limits the growth of *L. monocytogenes*. If an establishment chooses this alternative:

(i) The post-lethality treatment must be included in the establishment's HACCP plan. The antimicrobial agent or process used to suppress or limit the growth of the pathogen must be included in either the establishment's HACCP plan or its Sanitation SOP or other prerequisite program.

(ii) The establishment must validate the effectiveness of the post-lethality treatment incorporated in its HACCP plan in accordance with § 417.4. The establishment must document, either in its HACCP plan or in its Sanitation SOP or other prerequisite program, that the antimicrobial agent or process, as used, is effective in suppressing or limiting growth of *L. monocytogenes*.

(2) *Alternative 2.* Use of either a post-lethality treatment (which may be an antimicrobial agent) that reduces or eliminates microorganisms on the product *or* an antimicrobial agent or process that suppresses or limits growth of *L. monocytogenes*. If an establishment chooses this alternative:

(i) The post-lethality treatment must be included in the establishment's HACCP plan. The antimicrobial agent or process used to suppress or limit growth of the pathogen must be included in either the establishment's HACCP plan or its Sanitation SOP or other prerequisite program.

(ii) The establishment must validate the effectiveness of a post-lethality treatment incorporated in its HACCP plan in accordance with § 417.4. The establishment must document in its HACCP plan or in its Sanitation SOP or other prerequisite program that the antimicrobial agent or process, as used, is effective in suppressing or limiting growth of *L. monocytogenes*.

(iii) If an establishment chooses this alternative and chooses to use only an antimicrobial agent or process that suppresses or limits the growth of *L. monocytogenes*, its sanitation program must:

(A) Provide for testing of food contact surfaces in the post-lethality processing environment to ensure that the surfaces are sanitary and free of *L. monocytogenes* or of an indicator organism;

(B) Identify the conditions under which the establishment will implement hold-and-test procedures following a positive test of a food-contact surface for *L. monocytogenes* or an indicator organism;

(C) State the frequency with which testing will be done;

(D) Identify the size and location of the sites that will be sampled; and

(E) Include an explanation of why the testing frequency is sufficient to ensure that effective control of *L. monocytogenes* or of indicator organisms is maintained.

(iv) An establishment that chooses this alternative and uses a post-lethality treatment of product will likely be subject to more frequent verification testing by FSIS than if it had chosen Alternative 1. An establishment that chooses this alternative and uses an antimicrobial agent or process that suppresses or limits the growth of *L. monocytogenes* will likely be subject to more frequent FSIS verification testing than if it uses a post-lethality treatment.

(3) *Alternative 3.* Use of sanitation measures only.

(i) If an establishment chooses this alternative, its sanitation program must:

(A) Provide for testing of food contact surfaces in the post-lethality processing environment to ensure that the surfaces are sanitary and free of *L. monocytogenes* or of an indicator organism;

(B) Identify the conditions under which the establishment will implement hold-and-test procedures following a positive test of a food-contact surface for *L. monocytogenes* or an indicator organism;

(C) State the frequency with which testing will be done;

(D) Identify the size and location of the sites that will be sampled; and

(E) Include an explanation of why the testing frequency is sufficient to ensure that effective control of *L. monocytogenes* or of indicator organisms is maintained.

(ii) An establishment producing a deli product or a hotdog product, in addition to meeting the requirements of paragraph (b)(3)(i) of this section, must meet the following requirements:

(A) The establishment must verify that the corrective actions that it takes with respect to sanitation after an initial positive test for *L. monocytogenes* or an

indicator organism on a food contact surface in the post-lethality processing environment are effective by conducting follow-up testing that includes a targeted test of the specific site on the food contact surface area that is the most likely source of contamination by the organism and such additional tests in the surrounding food contact surface area as are necessary to ensure the effectiveness of the corrective actions.

(B) During this follow-up testing, if the establishment obtains a second positive test for *L. monocytogenes* or an indicator organism, the establishment must hold lots of product that may have become contaminated by contact with the food contact surface until the establishment corrects the problem indicated by the test result.

(C) Further, in order to be able to release into commerce the lots of product that may have become contaminated with *L. monocytogenes*, the establishment must sample and test the lots for *L. monocytogenes* or an indicator organism using a sampling method and frequency that will provide a level of statistical confidence that ensures that each lot is not adulterated with *L. monocytogenes*. The establishment must document the results of this testing. Alternatively, the establishment may rework the held product using a process that is destructive of *L. monocytogenes* or the indicator organism.

(iii) An establishment that chooses Alternative 3 is likely to be subject to more frequent verification testing by FSIS than an establishment that has chosen Alternative 1 or 2. An establishment that chooses Alternative 3 and that produces deli meat or hotdog products is likely to be subject to more frequent verification testing than one that does not produce such products.

(c) For all three alternatives in paragraph (b):

(1) Establishments may use verification testing that includes tests for *L. monocytogenes* or an indicator organism, such as *Listeria* species, to verify the effectiveness of their sanitation procedures in the post-lethality processing environment.

(2) Sanitation measures for controlling *L. monocytogenes* and procedures for antimicrobial agents or processes that suppress or limit the growth of the pathogen may be incorporated either in the establishment's HACCP plan or in its Sanitation SOP or other prerequisite program. When these control procedures are incorporated into the Sanitation SOP or prerequisite program, and not as a CCP in the HACCP plan, the establishment must have documentation that supports the decision in its hazard analysis that *L. monocytogenes* is not a hazard that is reasonably likely to occur.

(3) The establishment must maintain sanitation in the post-lethality processing environment in accordance with part 416.

(4) If *L. monocytogenes* control measures are included in the HACCP plan, the establishment must validate and verify the effectiveness of measures for controlling *L. monocytogenes* included in its HACCP plan in accordance with § 417.4.

(5) If *L. monocytogenes* control measures are included in the Sanitation SOP, the effectiveness of the measures must be evaluated in accordance with § 416.14.

(6) If the measures for addressing *L. monocytogenes* are addressed in a prerequisite program other than the Sanitation SOP, the establishment must include the program and the results produced by the program in the documentation that the establishment is required to maintain under 9 CFR 417.5.

(7) The establishment must make the verification results that demonstrate the effectiveness of the measures it employs, whether under its HACCP plan or its Sanitation SOP or other prerequisite program, available upon request to FSIS inspection personnel.

(d) An establishment that produces post-lethality exposed RTE product shall provide FSIS, at least annually, or more often, as determined by the Administrator, with estimates of annual production volume and related information for the types of meat and poultry products processed under each of the alternatives in paragraph (b) of this section.

(e) An establishment that controls *L. monocytogenes* by using a post-lethality treatment or an antimicrobial agent or process that eliminates or reduces, or suppresses or limits the growth of the organism may declare this fact on the product label provided that the establishment has validated the claim.

Done in Washington, DC: June 2, 2003.

Garry L. McKee,

Administrator.

Note: The following appendix will not appear in the Code of Federal Regulations.

Appendix A

Final Regulatory Impact Analysis

FSIS is amending its regulations to require that official establishments that produce certain ready-to-eat (RTE) meat and poultry products (MPPs) take measures to prevent product adulteration by *L. monocytogenes (Lm)*. These amended regulations primarily affect establishments that produce RTE MPPs that are exposed to the environment following lethality treatment and that support the growth of *Lm*.

The final rule takes into account the differences in the risk of *Lm* contamination by type of RTE MPP product and by the manner in which the pathogen is controlled in the production process. It takes into account these differences by identifying four alternative *Lm* control approaches applying to RTE MPPs that are exposed to the plant environment after undergoing a process that is lethal to the pathogen. Each alternative involves a different level of pathogen control and to each there corresponds a preferred level of monitoring and verification, based on science and the nature of the product.

Need for the Rule

This action is compelled by recent outbreaks of food borne illness related to the consumption of adulterated RTE meat and poultry products, coupled with information on the pathogenicity of the organism and the findings of the risk assessment and risk ranking conducted by FDA and FSIS. *Lm* contamination is often a result of post processing contamination or growth of the organism after it leaves the Federal establishment. FSIS concluded before beginning this rulemaking that many establishments were not effectively implementing HACCP plans and Sanitation SOPs to prevent *L. monocytogenes* from contaminating the RTE product in the post-lethality processing environment.

Given the pathogenicity of *L. monocytogenes*, the opportunity for it to contaminate RTE product in the post-lethality environment, and the significant consequences that this contamination can have, FSIS is amending its regulations. The Agency is adding provisions that require establishments that produce post-lethality exposed RTE product to include in their HACCP plans or in their Sanitation SOPs or other prerequisite programs measures that prevent product adulteration by *L. monocytogenes*.

Market Failure. This final rule addresses a market failure. Market failures occur when resources are misallocated or allocated inefficiently. Markets fail, in the current case, because processors may not always be provided with sufficient incentives to allocate the additional resources and efforts needed to provide effective prevention methods for pathogen contamination in their products. These incentives are lacking because consumers cannot identify (and reward) those firms that produce RTE MPPs and are implementing the desired food safety safeguards. Therefore, consumers are unable to distinguish these products from those produced by lower cost firms that are applying less effective pathogen prevention methods. The lack of information on the safety of the products produced by the establishments in this latter group is a major concern of this rule. The recent FSIS risk assessment clearly indicates that products from establishments that are not taking these precautions can lead to illness or death.

The provisions of this final rule are designed to provide establishments a choice of selected, proven technologies to minimize the presence of *Listeria* in their processing

environment. The use of these technologies and documentation of records on the environment of these establishments, brought about by this final rule, will provide the kind of information, and needed food safety assurance, that is lacking for consumers.

Rationale for the Approach Taken

The economic rationale for the requirements of the final rule is that it recognizes that a combination of interventions have been shown to be more effective that a single intervention and builds this into the framework of regulation. Second, the requirements recognize that the level of risk varies by product and how it is produced. Third, the requirements provide incentives for the establishment to adopt sanitation and testing practices that are most suitable for its products and processes. And lastly, these incentives for establishments have been shown to be preferable over mandatory requirements.

The FDA/FSIS risk ranking [1] found that RTE MPPs posed a moderate to high human health risk, particularly among vulnerable populations. These products include deli meats, hotdogs, meat spreads, pâté, and deli salads that include RTE meat or poultry products as components. The risk ranking indicates that among the RTE MPPs, deli meats pose an especially high risk.

The *FSIS Risk Assessment for L. monocytogenes in Ready-to-Eat Deli Meats* [2] (FSIS *Lm* risk assessment) estimated the reduction in fatalities among vulnerable populations from consuming contaminated deli meats that might be achieved through in-plant sanitation with verification testing regimes of increasing intensity. These results were compared with estimates for similar fatality reductions that might be achieved by applying post-lethality treatments or growth inhibiting additives or processes. Based on the finding of the FSIS *Lm* risk assessment, the Agency concluded that a combination of interventions, including sanitation coupled with verification testing, and the use of growth inhibitors, appears to be more effective in controlling *Lm* than a single intervention in these operations.

FSIS considered the findings of the FDA/FSIS risk ranking and the Agency's *Lm* risk assessment and the public comments that had been submitted on the Agency's proposed rule regarding control of *Lm* in RTE products. Many of the comments expressed opposition to proposed mandatory testing frequencies—either the frequencies themselves or the fact that they would be mandated. Instead of mandatory testing requirements, the Agency is requiring that establishments incorporate appropriate verification methods into their HACCP plan, Sanitation SOP, or prerequisite program. This approach provides establishments with incentives to test for *Lm* and the flexibility to implement control measures that are appropriate for the types of products produced and processing methods at the establishment.

The final rule sets out four alternative *Lm* control approaches. For the purposes of this analysis, FSIS has grouped the affected establishments according to their use of these *Lm* control approaches.

Changes Between the Proposed and the Final Rule

FSIS considered four regulatory options for this final rule that had been generated from comments on the proposed rule. The options were: (1) No action; (2) a sanitation performance standard for reduction of *Lm* in RTE MPPs; (3) mandatory testing frequencies for *Listeria* species on food contact surfaces different from the frequencies proposed; and (4) a warning label to inform consumers in vulnerable groups of the potential for *Lm* contamination.

FSIS determined that: (1) Comments supported a final rule; (2) scientific support for a sanitation performance standard was lacking; (3) mandatory testing frequencies were objectionable for reasons given in the comments; (4) a warning label would be inappropriate because, under the law, all RTE meat and poultry products must be not adulterated and thus safe for all consumers.

FSIS adopted a modification of the third option. It will require establishments to describe their testing programs in their HACCP plans or in their Sanitation SOPs or other prerequisite programs, as appropriate for products and processing technologies. It will also require establishments to set the frequency of their verification tests for *Lm* on food contact surfaces, but will not mandate a specific frequency. The *Lm* control alternative influences the frequency of verification testing at an establishment. Verification testing is expected to be most frequent for establishments that produce post-lethality exposed deli meats and hotdogs and rely exclusively on sanitation and verification testing to control *Lm*.

The final rule identifies four *Lm* control alternatives that are typical of industry practices. The purpose of these control alternatives is to link the usage of HACCP or sanitation procedures with the risk of *Lm* contamination based on the FDA/FSIS risk ranking and the FSIS *Lm* risk assessment. The control approaches are: (1) A HACCP-based post-lethality treatment plus *Lm* growth limiting measures; (2) a HACCP-based post-lethality treatment or *Lm* growth limiting measures; (3) solely sanitation and verification control measures in its post-lethality treatment and no *Lm* growth inhibiting measures—and producing a class of post-lethality exposed product that is not a deli product or a hotdog product; and (4) solely sanitation and verification control measures in its post-lethality treatment and no *Lm* growth inhibiting measures—and producing a class of post-lethality exposed product that is a deli product or a hotdog product. For the purposes of this analysis, FSIS has grouped all establishments producing RTE MPPs that are exposed post-lethality according to their current and expected use of these *Lm* control approaches and this analysis will refer to these establishment groups as establishment group (EG) 1 through 4.

The proposed rule would have required RTE MPP establishments to control *Lm* either in their HACCP plans or their Sanitation SOPs. The final rule requires establishments to include post-lethality treatments in their HACCP plans and allows them to have other types of *Lm* contamination controls in their HACCP plans or in their Sanitation SOPs or other prerequisite programs. This modification of the proposal is based on the finding that the establishment's use of a post-lethality treatment represents a determination by the establishment that *Lm* is a hazard reasonably likely to occur.

The prerequisite program provisions in the final rule respond to comments that the Agency should provide establishments with greater flexibility in implementing *Lm* contamination controls. In particular, RTE MPP establishments usually do not control post-processing contamination through HACCP alone, but through a variety of prerequisite programs.

In response to public comments, the final rule also does not mandate food contact surface (FCS) testing frequencies. Instead, the final rule sets out specific requirements, for Alternatives 2 and 3 for sanitation procedures that are included in HACCP plans, or in Sanitation SOPs or other prerequisite programs. Establishments are allowed to choose their own testing methods and frequencies for verifying the effectiveness of their procedures.

The sanitation procedure requirements for Alternative 3 establishments that process hotdog and deli meat products and control for *Lm* using sanitation procedures only, include hold-and-test provisions. These procedures are invoked when follow-up testing to verify corrective actions in response to *Listeria*-positive FCS test results. A second positive FCS test for *L. monocytogenes* or an indicator organism entails withholding from commerce product that was in contact with the contaminated surface. Shipments can resume when subsequent tests in the same area of the plant are negative. The product can be tested under a sampling plan that provides sufficient confidence to enable the product to be released into commerce. The requirements for Alternative 3 establishments that process deli meats and hotdogs represent a modification of the hold-and-test procedures that the proposal would have required (proposed § 430.4(b)) but imposes this requirement only on establishments producing hotdog and deli-meat type products. This particular change from the proposal is responsive to comments opposing mandatory testing frequencies and the proposed hold-and-test requirements, which would have applied to all RTE MPPs. The requirements for Alternative 3 establishments that process deli meats and hotdogs are also responsive to the FDA/FSIS risk ranking which identified hot dog and deli-meat products as posing a moderate to high risk for listeriosis on a per annum basis (as opposed to a per serving basis), and the FSIS *Lm* risk assessment which evaluated the risk-reduction effectiveness of various

[1] FDA, FSIS, CDC. "Draft Assessment of the Relative Risk to public Health from Foodborne Listeria monocytogenes Among Selected Categories of Ready-to-Eat Foods". The document is available at *www.foodsafety.gov*.

[2] USDA, FSIS. "Draft Risk Assessment for Listeria monocytogenes in Ready-to-eat Deli Meat Products". FSIS. March 2003. The risk assessment is available at *www.fsis.usda.gov*.

combinations of in-plant interventions, including FCS testing, with and without test and hold actions.

The final rule also differs from the proposal by requiring RTE MPP establishments to furnish FSIS with at-least-annual estimates of production volume by type of RTE MPP and by alternative *Lm* control program used. This change responds to comments on the proposed rule indicating opposition to the use of establishment size criteria in determining verification testing intensity and to information provided in the public comments indicating that there may not be a connection between establishment size and volume of production. These comments noted that production volume is dependent on factors other than establishment size, such as technology.

Finally, the rule allows labels on RTE MPPs to show that the products were processed in a manner to eliminate, reduce, or limit the growth of *Lm*, provided that the claim is validated. This provision is not a regulatory requirement in that it does not mandate such labeling, but is intended to encourage the industry to implement effective *Lm* controls and to provide useful information to consumers, especially vulnerable subpopulations.

Coverage

FSIS found that that the final rule will affect 2,930 federally inspected RTE MPP establishments and about 2,046 State-inspected establishments. About 144 of these establishments are considered large, 1,276 small and 3,556 very small, using the size criteria adopted by FSIS in implementing the HACCP regulations. FSIS was able to determine that the baseline numbers of federally and State-inspected establishments in the respective *Lm* control groups 1 through 4 are, respectively: 49; 2,297; 1,864; and 766. These numbers are expected to change as a result of this rule.

FSIS was further able to determine that, because of the intensity of verification testing that sanitation-and-testing establishments would have to implement to ensure that product contaminated with *Lm* is not shipped, a certain percentage of establishments in this group are likely to decide to put their *Lm* controls in their HACCP plans or to adopt *Lm* growth suppressing or limiting methods. They would decide, therefore, to "move or migrate" into the grouping of establishments that take either the first or the second *Lm* control approach. The number of establishments in establishment groups 1 through 4 is expected to be 95, 2,363, 1,864, and 654, respectively, after the final rule goes into effect. The expected movement among establishment groups is discussed in detail in a later section.

The numbers of establishments in each of these *Lm* control groupings will determine the allocation of FSIS inspection resources for *Lm* control verification. FSIS will verify that establishments that produce RTE products are carrying out *Lm* control procedures in their post-lethality processing areas as described in their HACCP plans or their Sanitation SOPs or other prerequisite programs, and that they are complying with the requirements of this final rule. In addition to verifying establishment *Lm* controls, the Agency will verify that any label claims regarding *Lm* control have been validated. The frequency of FSIS verification testing of establishment *Lm* controls is expected to be higher for each successive *Lm* control alternative. In other words, the frequency will be lowest for establishments that use control Alternative 1 and highest for establishments that use control alternative 3 and that produce deli meats and hotdogs.

Establishment Groups

Grouping by Control Method. For the purposes of this analysis, four establishment groups can be identified in the final rule. The four groups are composed respectively of the establishments choosing *L. monocytogenes* control Alternatives 1 through 3, and the deli meat- and hotdog-producing establishments choosing Alternative 3 (9 CFR 430.4(b)(1), (b)(2), (b)(3)(i) and (b)(3)(ii)):

Establishment Group One (9 CFR 430.4(b)(1)): Establishments apply a post-lethality (PL) treatment to their products or process and use a *Lm* growth inhibiting agent or process. Products produced by establishments in EG 1 are expected to present the least risk of possible *Lm* contamination of products because they use a combination of intervention measures. EG 1's HACCP, Sanitation SOP or other prerequisite program controls and FSIS's "normal" verification procedures are expected to provide information that is adequate to assure the establishment and FSIS inspection personnel that an adulterated product is not being produced.

Establishment Group Two (9 CFR 430.4(b)(2)): Establishments apply either a post-lethality treatment to their products or use a *Lm* growth inhibiting agent or process. Because establishments in EG 2 apply a PL treatment to their products or use a growth inhibiting agent or process, but not both, this group's products present a somewhat higher level of risk. They still would be considered "safe" with a high degree of certainty, but this final rule will provide additional assurance that the products are not adulterated by requiring EG 2 establishments to test food contact surfaces (FCSs) and make the test results available to FSIS.

Establishment Group Three (9 CFR 430.4(b)(3)(i)): Establishments use neither a PL treatment nor a growth inhibiting agent or process, but has Sanitation standard operating procedures (Sanitation SOP) or other prerequisite programs and produce a class of post-lethality exposed product that is not a deli product or a hotdog product.

Establishment Group Four (9 CFR 430.4(b)(3)(ii)): Establishments use neither PL treatments nor *Lm* growth inhibiting agents or processes in their RTE MPP production, but have Sanitation SOP or other prerequisite programs and produce a class of post-lethality exposed product that is a deli product or a hotdog product. Establishments in EG 4 produce RTE MPPs that have been identified in recent risk assessments as posing significant risk of *Lm* contamination in their post-processing environment and significantly contribute to illnesses and deaths. The *Lm* control measures for establishments in EG 4 are similar to those of EG 3, but FSIS feels that specific holding action requirements are justified to ensure that no adulterated product enters commerce when a second consecutive positive FCS test in the post-lethality processing environment of a EG 4 is found. A guide to the final rule requirements by establishment group is given in Table 1.

BILLING CODE 3410–DM–P

Table 1. Summary of final rule requirements by establishment group.

Item	Establishment Group			
	1	2	3	4
(1) Inclusion of a PL treatment to their product or process as a CCP in the establishment's HACCP plan.	R	R	NR	NR
(2) Validation of (1) as being effective in eliminating L. monocytogenes.	R	R	NR	NR
(3) Verification of (1) to be effective in accordance with 417.4 on a continuous basis and provision of them to FSIS.	R	R OR	NR	NR
(4) Apply a bacteriostatic agent or process that eliminates L. monocytogenes growth in the product.	R	R	NR	NR
(5) Validation of (4) as being effective in eliminating L. monocytogenes.	R	R	NR	NR
(6) Verification of (4) to be effective in accordance with 417.4 on a continuous basis and provision of them to FSIS.	R	R	NR	NR
(7) FCS testing with a frequency determined by the establishment to be effective.	NR	R	R	R
(8) Provision of FCS testing results to FSIS.	NR	R	R	R
(9) Establishment's sanitation plan explains how FCS is kept sanitary and free of L. monocytogenes.	NR	R	R	R
(10) Specific requirements on holding of each lot of product associated with two consecutive FCS positives, until two consecutive FCS negatives.	NR	NR	NR	R

NR = Not required; R = Required.

BILLING CODE 3410–DM–C

Analysis of Costs

Number of Establishments. The preliminary regulatory impact analysis relied on the 1997 Census of Manufacturers for an initial count of RTE MPP establishment numbers. 1,630 establishments were identified as producing a RTE MPP. The estimated number of establishments affected by the proposed rule was expected to be fewer than the actual number total for many reasons, but chiefly because the Census classifies businesses according to their principal activity. In some cases, the production of RTE MPP might be a secondary activity. This undercounting was a major deficiency in the preliminary regulatory impact analysis (PRIA). FSIS has corrected this problem and is estimating the impacts of the final rule considering both federally and State-inspected establishments producing RTE MPPs.

Basing the analysis on a more realistic estimate of the number and types of establishments affected by the rule provides a better estimate of industry impacts. However, using this approach, the product-specific information, such as the value of production, that was available through Census data, cannot be used. Also, certain assumptions must be made in manipulating the data for both federally and State-inspected establishments to avoid double counting and to estimate HACCP process categories for RTE MPPs at State-inspected establishments.

FSIS used the 2001 Performance-Based Inspection System (PBIS) databases to identify Federal-inspected establishments that have at least one HACCP process category code (actually, the pertinent procedure code from FSIS's inspection system procedure guide) associated with a RTE MPP. The 2001 PBIS database showed that there were 2,930 federally inspected establishments with 3,556 HACCP process category codes associated with RTE MPPs. Establishments were grouped into HACCP establishment size categories by cross tabulating this data with the 2001 Enhanced Facilities Database (EFD). (HACCP establishment size categories have been defined since the publication of the PR/HACCP rule (61 FR 38806; July 25, 1996) as large: more than 500 employees; small: between 499 and 10 employees; and very small: Fewer than 10 employees or less than $2.5 million in annual sales.) To obtain the number of unique establishments in each HACCP process category code, the number of HACCP plans for each HACCP process code was divided by the average number of HACCP plans per establishment in each size category (bottom of Table 2).

The EFD identified 2,046 State-inspected RTE MPP establishments comprised of 1,992 very small establishments and 54 small establishments. To obtain an estimate of the product types produced at State-inspected plants, the total number of State-inspected establishments was distributed across the four HACCP process category codes in the same proportion that was found in federally inspected establishments (Table 3).

BILLING CODE 3410–DM–P

Table 2. Federally inspected RTE MPP establishments by HACCP process category code, 2002.

Item	HACCP Establishment Size Category			Total
	L	S	VS	
O3E- Not heat-treated, shelf-stable	5	68	88	161
O3F- Heat-treated, self-stable	41	238	405	684
O3G-Fully cooked, not shelf-stable	122	1,079	1,319	2,520
O3I-Product w/ secondary inhibitors	9	68	72	149
Total HACCP plans	177	1,453	1,884	3,514
Total Unique Federally inspected Establishments	144	1,222	1,564	2,930
HACCP plans/establishment	1.23	1.19	1.20	1.20

"Adjusted" number of federally-inspected establishments by HACCP Process Category Code (Number of HACCP Process Category Codes by Size Category divided by HACCP plans/establishment)

Item	L	S	VS	Total
O3E- Not heat-treated, shelf-stable	4	57	73	134
O3F- Heat-treated, self-stable	33	200	336	570
O3G-Fully cooked, not shelf-stable	99	907	1,095	2,101
O3I-Product w/ secondary inhibitors	7	57	60	124
Total Federal-inspected RTE MPP establishments	144	1,222	1,564	2,930

Table 3. State-inspected RTE MPP establishments by HACCP process category code, 2002.

Item	Distribution of federally-inspected establishments			
HACCP Process Category Code	HACCP Establishment Size Category			Total
	L	S	VS	
	Percent			
O3E- Not heat-treated, shelf-stable	2.8	4.7	4.7	4.6
O3F- Heat-treated, self-stable	23.2	16.4	21.5	19.5
O3G-Fully cooked, not shelf-stable	68.9	74.3	70.0	71.7
O3I-Product w/ secondary inhibitors	5.1	4.7	3.8	4.2
Total Federal-inspected RTE MPP establishments	100	100	100	100
Item	"Adjusted" number of State-inspected establishments			
O3E- Not heat-treated, shelf-stable	0	3	93	96
O3F- Heat-treated, self-stable	0	9	428	437
O3G-Fully cooked, not shelf-stable	0	40	1,395	1,435
O3I-Product w/ secondary inhibitors	0	3	76	79
Total State-inspected RTE MMP establishments	0	54	1,992	2,046

Table 4. Total number of RTE MPP Federally and State-inspected establishments by HACCP process category code, 2002.

Item	HACCP Establishment Size Category			Total
HACCP Process Category Codes	L	S	VS	
O3E- Not heat-treated, shelf-stable	4	60	166	230
O3F- Heat-treated, self-stable	33	209	764	1,007
O3G-Fully cooked, not shelf-stable	99	948	2,490	3,536
O3I-Product w/ secondary inhibitors	7	60	136	203
Total RTE MPP establishments	144	1,276	3,556	4,976

BILLING CODE 3410–DM–C

The total number of establishments producing RTE MPP products is estimated to be 4,976: 59 percent federally inspected and 41 percent State-inspected. Of the total, 4.6 percent are associated with the O3E HACCP code; 20.2 percent with the O3F code; 71.1 percent with the O3G code; and, 4.1 percent with the O3I code (Table 4). Further analysis of HACCP size categories shows that 71.5 percent of all RTE MPP establishments are very small; 25.6 percent are small; and, 2.9 percent are large.

Product groups. The PRIA classified RTE MPP establishments by the expected range of potential cost impact on those establishments: Those likely to incur the greatest costs, moderate costs, minor costs, and no likely costs (Table 3 in **Federal Register**, Vol. 66, No. 39). This grouping was based on the likely impact from both the proposed testing programs as well as the proposed changes in lethality and stabilization performance standards. The final rule concerns only that section of the proposed rule dealing strictly with FSIS's desire to increase safeguards with respect to possible *Lm* contamination. Because of this and also because products and production processes vary across the same product classification, it is not feasible to disaggregate in the fashion of the PRIA. However, it appears that the largest impact will be on establishments producing cooked RTE MPP products—those products associated with HACCP process code O3G. There is little likelihood that there will be any cost impact on RTE MPP establishments producing products in the O3E, O3F and O3I HACCP process codes, except for costs attributable to a possible increase in FCS testing mandated by the rule. These costs are expected to be minor because many of the establishments in the HACCP process category codes already apply an agent or process that inhibits *Lm* growth so many of these establishments "qualify" to be classified in EG 2.

Establishments associated with the O3G HACCP process category code produce cooked RTE MPPs which may or may not be able to apply post-lethality treatment to products, apply antimicrobial agents, or include procedures in either Sanitation SOPs or prerequisite programs. In some cases, FCS testing and disclosure of those results to FSIS may result in minor cost increases similar to those for 03E, 03F, and 03I HACCP process category codes. For other products in the 03G HACCP process code, they could be produced under any of the four alternative post-lethality *Lm* control regimes identified in this final rule. In those cases, the costs could be significantly higher. Accordingly, the cost impact discussion is presented by each establishment group, type of products produced, and their associated establishment numbers and size distribution.

Impacts according to establishment group. The Agency anticipates that the measures taken by establishments will differ by establishment group. The following describes the major types of responses expected to be taken in response to the final rule for those establishments switching establishment groups and/or validating current *Lm* controls.

EG 1 EG 2 Impacts

(1) *Incorporation of post-lethality treatments and/or their validation for FSIS:* Many establishments are currently using post-lethality measures to address possible *Lm* contamination. These actions may have been taken in response to client requirements, the recent FSIS *Lm* intensified verification program, or in anticipation of further FSIS action. The costs of these actions taken by establishments are not attributed to the final rule. However, measures taken to satisfy this requirement or to validate these measures to FSIS are attributed to the final rule. These measures include: Post-lethality heating (may not be feasible for many products, especially those with a high fat content); high-pressure systems, which may be limited to a few specialty items and usually have a low throughput; and irradiation, which is not permitted to be applied to RTE MPPs at present. FSIS expects establishments using post-lethality treatments to verify that their treatments are effective and also to monitor FCSs to assure that the treatment is effective. This level of verification FCS testing for establishments in EG 1 is expected to be about twice yearly.

(2) *Use of agent in product formulation or change in processes to inhibit* Lm *growth in product:* FSIS has recently permitted the use of certain food additives that inhibit *Lm* growth (65 FR 17128, March 31, 2000). These additives include lactate and diacetates that have been applied increasingly to cooked and cured RTE MPPs such as hotdogs. The cost to establishments of taking measures involving the use of these additives is not attributable to the final rule. The Agency estimates that up to 70 percent of all hotdog manufacturers have recently changed their product formulations to incorporate one of the recently permitted food additives. Changes in a process that would help inhibit the *Lm* growth in the product include: lowering the pH or water activity levels and refrigerating or freezing the product following processing. Growth inhibiting processes uses antimicrobial agents to control growth in post-lethality exposed products such as many hotdogs and certain other kinds of sausages. Verification FCS testing for establishments in EG 2 would be expected at least once per quarter. This level of testing would be expected whether the establishment administered a PL treatment or applied a *Lm* growth inhibiting agent or included a process in either a Sanitation SOP or prerequisite program.

EG 3 and EG 4 Impacts

(1) *FCS testing frequencies:* For the purpose of this analysis, the minimum level of FCS testing expected for establishments in EG 3 is at least once per month: once a month for high, once a month for small, and once a month for very small establishments. Also, the minimal level of FCS testing for EG 4 is: at least weekly for high-volume establishments, semi-monthly for small volume establishments, and monthly for very small (or low volume) establishments (4–2–1). These testing frequencies are illustrative in that the actual testing frequencies incorporated into final compliance guidelines may differ.

A potential unintended impact of the rule for establishments in EG 4 might be the incentive to reduce their current level of FCS testing if results are to be shared with FSIS. An establishment in this group may conduct fewer tests if results could lead to costly hold-and-test actions. This potential unintended impact was not be quantified in this analysis.

EG 4 Impacts

(1) *Hold and Test:* EG 4 establishments may be unable to (1) apply a post-lethality treatment or (2) apply an agent or include a process in either the Sanitation SOP or prerequisite program for a variety of reasons. Product from these establishments can be held on the basis of FCS testing results shared with the Agency. Multiple episodes of holding product may be incurred in the case of two consecutive positive FCS test results.

Baseline

Establishment Types. The compliance cost impacts of the rule differ significantly among establishment groups and by HACCP size category. The current distribution of establishments by group and size serves as the baseline for determining the distribution of compliance cost and also the starting point for the expected establishment shifts among establishment groups discussed below.

Table 4 indicates that 1,440 establishments produced RTE MPPs in the O3E, O3F, and O3I HACCP process category codes. For purposes of this analysis, these establishments are distributed 90 percent in EG 2 and 10 percent in EG 3. The high proportion in EG 2 is a result of the use of growth inhibitors in most of these products which include cured and salted products. These products have not been associated with listeriosis outbreaks.

The remaining 3,536 establishments in O3G produce cooked RTE MPPs that may be produced by any of the four Lm control methods. These establishments were partitioned into the four establishment groups as follows:

(1) From a December 2002 FSIS hotdog and deli meat survey, we know that there are 1,712 operations producing hotdogs and/or deli meats. Given that 38 percent of these operations produce both hotdogs and deli meats, the actual number of unique establishments involved is 1,061 ((1 − .38) × 1,712).

(2) The number of establishments producing cooked products other than hotdogs and/or deli meats was estimated by subtracting the number of single establishments producing hotdogs and/or deli meats from the total number of establishments producing cooked products (3,536 − 1,061 = 2,475).

(3) FSIS inspection program personnel were contacted to estimate the proportion of establishments producing hotdog/deli meat and other cooked products in each of the establishment groups. These estimates, provided in Tables 5 and 6, were used to partition the establishments producing hotdog and deli meats and the other cooked RTE MPPs by establishment group (Table 7).

BILLING CODE 3410–DM–P

Table 5. Percentage of hotdog and deli meat establishments by establishment group, 2002

Item	HACCP Establishment Size Category		
Establishment group	L	S	VS
1	0.15	0.05	0.03
2	0.65	0.30	0.12
3	0.00	0.00	0.00
4	0.20	0.65	0.85

Source: FSIS Hotdog and deli meat industry survey, December 2002.

Table 6. Percentage of remaining establishments in O3G Code by establishment group, 2002

Item	HACCP Establishment Size Category		
Establishment group	L	S	VS
1	0.00	0.00	0.00
2	0.75	0.50	0.25
3	0.25	0.50	0.75
4	0.00	0.00	0.00

Source: FSIS inspection program personnel, January 2003.

Table 7. Total number of RTE MPP Federally and State-inspected establishments by establishment group, 2002.

Item	HACCP Establishment Size Category			
Establishment Group	L	S	VS	Total
1	9	24	16	49
2	108	675	1514	2297
3	13	269	1581	1864
4	13	308	445	766
Total RTE MPP establishments	143	1276	3556	4976

BILLING CODE 3410–DM–C

Health Consequences. The baseline for comparing human health benefits associated with the rule is established by the "Draft FSIS Risk Assessment for *Listeria Monocytogenes* in Ready-to-eat Deli Meat Products"[3] (*Lm* Risk Assessment). The *Lm* Risk Assessment concludes that 320 deaths are attributable to RTE deli meats. It is not possible at this time to identify the number or deaths attributable to RTE MPPs, which in addition to deli meats includes hotdogs, fermented sausages, and related products.

The FDA/FSIS risk ranking model[4] estimates that there are about 340 billion servings of all RTE products consumed per year. RTE MPPs are contained within the following classes: reheated franks, non-reheated franks, deli meats, fermented sausages, pâté, and deli-salads. These classes comprise about 43 billions servings. The deli meat class is responsible for 49 percent of the 43 billion servings of RTE MPP. The two hotdog classes are together responsible for 15 percent of the servings of RTE MPP. Based on these estimates, there could be as many 375 annual fatalities associated with RTE MPPs.

The *Lm* Risk Assessment, because of its focus on deli meats, is only able to estimate the human health benefits associated with the rule as it affects this category of products. For purposes of establishing a baseline for potential human health benefits, deli meats are divided into two categories: Products sliced and packaged at the establishment; and retail sliced product. Pre-packed products are post-lethality exposed and the focus of the regulation. Retail-sliced products are not post-lethality exposed until prepared for use or sale at a retail location. The human health exposure to each type of product is a function of its share of total RTE deli meats consumed and the level of contamination in each type of product. Actions by FSIS can reduce the exposure to some, but not all RTE deli meat.

The Economic Research Service estimates that pre-packaged product accounts for 46 percent ($11.6 billion) of total sales of RTE deli meats ($25.2 billion) and retail sliced product the remaining 54 percent ($13.6 billion).[5] Volume of product in the categories would provide a more suitable basis for establishing a baseline level.

There is considerable uncertainty about the level of contamination in each type of product when purchased. A recent study by Gombas, Chen, Clavero, and Scott[6] finds that there is a 0.4 percent prevalence rate for *Lm* in pre-packaged product and a 2.7 percent prevalence rate for *Lm* in retail sliced product at the retail level. If 0.4 percent of pre-packaged product was found to be contaminated at the processing plant, it follows that 0.4 percent of the 2.7 percent prevalence rate at retail might be due to contamination at the processing site. That means that the prevalence of product solely contaminated during retail slicing is 2.3 percent (the observed 2.7 percent minus the 0.4 percent that was contaminated at the processor site). Using this information and the relative market share weights for pre-packaged and retail sliced deli meats from ERS provides a weighted average exposure rate for deli meats: .004(0.46) + 0.004(0.54) + .027 (.54) = .0164 or, .004 + .01242 = .01642

The pre-packaged product share of the weighted average exposure rate is 24.4 percent (.004/.01642 = 0.2436) and the retail sliced product share is the remaining 75.6 percent. Therefore, the human health baseline risk which the FSIS can affect at federally inspected establishments is a potential maximum 78 deaths (24.4 × 320).

The Agency has several concerns about this approach to establish a baseline level of human health risk. The prevalence levels estimated by Gombas, *et al.* and based on National Food Processing Association (NFPA) Survey data, taken at retail establishments, are significantly lower than those found by FSIS and reported in the *Lm* Risk Assessment Model. Levine, *et al.*[7] reported 1999 prevalence levels of *Lm* at 2.71 percent for cooked, roast, and corned beef and 4.58 percent in sliced ham and other pork luncheon meats. All samples were collected at production facilities, not at retail. The prevalence levels from the NFPA and FSIS studies are not entirely comparable, but they do seem to be inconsistent, even after taking into account basic limitations in the data used in both studies. The NFPA survey data describe the difference in prevalence between product contaminated at processing and product contaminated at retail. It is important to recognize that some of the product found contaminated at retail was contaminated at the processor but was only detected at retail. It is difficult to reconcile FSIS product sampling which finds 2.7–4.6 percent of RTE meats positive for *Lm*, with the finding based on the NFPA survey data that only 0.4 percent of packaged RTE meats are positive at retail outlets. Some net growth, not dying off, of *Lm* within contaminated packages between processor and retail is expected. The Agency concludes that there is much uncertainty about the true proportion of products contaminated at the processor and at the retail facility and among products affected by the rule and not affected by the rule.

All things considered, the Agency concludes that it is appropriate to make at least a 50-percent reduction in the potential deaths and illnesses averted due to *Lm* control measures taken by RTE MPP establishments as a result of this rule (versus the 24.4 percent based on the estimate presented). This percentage takes into account the study by Gombas, *et al.*, and discussions with FSIS industry experts, risk assessors, and microbiologists. Consequently, the maximum potential reduction in fatalities achieved through Agency measures for RTE deli meat products is 180 (320 × .5). This level would be somewhat higher if hotdogs, fermented sausage, and related products were included in the *Lm* Risk Assessment.

Expected Movement Among Establishment Groups

There are six major industry cost impacts that are expected with the final rule. Most of these impacts arise because some establishments are expected to shift into establishment groups that entail different technologies than they currently employ. These shifts are attributed to compliance with requirements of the rule. Costs are estimated on the basis of such shifts among the establishment groups. The movements among establishment groups are based on the experience and judgment of FSIS personnel which were pooled together to produce certain guidelines to estimate the expected movement of establishments across establishment groups, depending on their establishment size. For large establishments, it is expected that, based on this collective judgment, 20 percent of the establishments in EG 2 (that were already applying a PL treatment and referred to as EG 2A) would move into EG 1 (Table 8). These seven establishments already had the necessary equipment for these treatments, but simply had not validated their use. Therefore, only very little additional cost was involved for these establishments to move into EG 1 (along with the adoption of applying a *Lm* inhibiting agent or process). A 10-percent shift in establishments in EG 2B and EG 4 is expected because these establishments have not incurred the high initial costs of the post lethality equipment, resulting in a shift of seven establishments from EG 2B and two from EG 4. No establishment shifts in EG 3 are anticipated. In total, the application of these guidelines produced an increase of 16 establishments in EG 1 (Table 9).

BILLING CODE 3410–DM–P

[3] USDA, FSIS. "Draft Risk Assessment for Listeria Monocytogenes in Ready-to-eat Deli Meat Products". FSIS. March 2003. The risk assessment is available at *www.fsis.usda.gov.*

[4] FDA, FSIS, CDC. "Draft Assessment of the Relative Risk to Public Health from Foodborne Listeria Monocytogenes Among Selected Categories of Ready-to-Eat Foods". The document is available at *www.foodsafety.gov.*

[5] The estimate is based on information from the A.C. Nielson Co. 2001 Consumer Expenditures Study as reported in *Progressive Grocer,* September, 2002. The data sources are: supermarket checkout scanner data from a representative sample of 10,000 U.S. supermarkets, a representative consumer panel consisting of 55,000 households, and *Progressive Grocer* estimates.

[6] "Survey of Listeria monocytogenes in Ready-to-Eat Foods", *Journal of Food Protection* 66 (H): 559–569.

[7] Levine P, Rose B, Green S, Ransom G, and Hill W (2001). Pathogen testing of ready-to-eat meat and poultry products collected at federally-inspected establishments in the United States, 1990 to 1999. Journal of Food Protection 64(8):188–1193.

Table 8. Rules employed in estimating large establishment shifts across establishment groups.

	Went to:				Came from:		
Estab. Group	1	2A	2B	4	2A	2B	4
1	NA	--------	----------	--------	20% of 34	10% of 74	10% of 13
2A /1	2A-1 above.	NA	----------	--------	----------	----------	----------
2B /1	2B-1 above.	--------	NA	--------	----------	----------	25% of 13
3	----------	--------	----------	--------	----------	----------	----------
4	4-1 above.	--------	4-2B above.	NA	----------	----------	----------

/1 2A refers to those establishments applying only a PL treatment; 2B refers to those establishments applying only a Lm inhibiting agent or process to their product or process.

Table 9. Absolute levels and changes in large establishments across establishment groups.

Item	Start and End Levels			Went to:					Came from:			
Estab. Group	Old	New	Change	1	2A	2B	4	Total	2A	2B	4	Total
1	9	25	16	0	0	0	0	0	7	7	2	16
2A /1	34	27	-7	-7	0	0	0	-7	0	0	0	0
2B /1	74	70	-4	-7	0	0	0	-7	0	0	3	3
3	14	14	0	0	0	0	0	0	0	0	0	0
4	13	8	-5	-2	0	-3	0	-5	0	0	0	0
All Estab.	144	144	0	-16	0	-3	0	-19	7	7	5	19

/1 2A refers to those establishments applying only a PL treatment; 2B refers to those establishments applying only a Lm inhibiting agent or process to their product or process.

BILLING CODE 3410–DM–C

For small establishments, the combination of the high cost of technologies involved in EG 1 and/or EG 2 plus their limited volume of production is expected to lower their propensity for establishments to shift to another establishment group. Also, characteristics of their products and their production are expected to limit establishment shifts. Because of these constraints, it is expected that only 31 establishments (or 10 percent of the small establishments in EG 4) are likely to migrate to EG 1 as a result of the final rule (Table 10). Recall that all such movement involves the purchase and use of new technology. For most of these establishments, the option of adding a *Lm* inhibiting agent or process is probably a more attractive, least-cost option. As a result, 25 percent of the existing number of small establishments in EG 4 (or 77 establishments) is expected to shift into EG 2. No small establishments in EG 3 are expected to shift establishment groups. In total, 108 small establishments are expected to shift from EG 4 into either EG 1 or EG 2 (Table 11).

BILLING CODE 3410–DM–P

Table 10. Rules employed in estimating small establishment shifts across establishment groups.

	Went to:				Came from:		
Estab. Group	1	2A	2B	4	2A	2B	4
1	NA	--------	----------	--------	----------	----------	10% of 308
2A /1	----------	NA	----------	--------	----------	----------	----------
2B /1	----------	--------	NA	--------	----------	----------	25% of 308
3	----------	--------	----------	--------	----------	----------	----------
4	4-1 above.	--------	4-2B above.	NA	----------	----------	----------

/1 2A refers to those establishments applying only a PL treatment; 2B refers to those establishments applying only a Lm inhibiting agent or process to their product or process.

Table 11. Absolute levels and changes in small establishments across establishment groups.

Item	Start and End Levels			Went to:					Came from:			
Estab. Group	Old	New	Change	1	2A	2B	4	Total	2A	2B	4	Total
1	24	55	31	0	0	0	0	0	0	0	31	31
2A /1	114	114	0	0	0	0	0	0	0	0	0	0
2B /1	561	638	77	0	0	0	0	0	0	0	77	77
3	269	269	0	0	0	0	0	0	0	0	0	0
4	308	200	-108	-31	0	-77	0	-108	0	0	0	0
All Estab.	1276	1276	0	-31	0	-77	0	-108	7	7	108	108

/1 2A refers to those establishments applying only a PL treatment; 2B refers to those establishments applying only a Lm inhibiting agent or process to their product or process.

BILLING CODE 3410–DM–C

For very small establishments, the combination of high costs associated with technologies necessary to "qualify" for EG 1 or EG 3 and the nature of their product or production is expected to make it highly unlikely that any establishment will move into a different establishment group as a result of this final rule. The total expected establishment movements expected as a result of this final rule are given in the table below (Table 12).

Table 12. Changes in all establishments across establishment groups.

Item	Establishment Size			
Establishment Group	Large	Small	Very Small	Total
1	16	31	0	+47
2A /1	-7	0	0	-7
2B /1	-4	77	0	+73
3	0	0	0	0
4	-5	-108	0	-113
All Establishments	0	0	0	0

/1 2A refers to those establishments applying only a PL treatment; 2B refers to those establishments applying only a Lm inhibiting agent or process to their product or process.

Cost to validate a post-lethality treatment r establishments in EG 1 and EG 2. It is expected that 43 HACCP plans of 35 establishments (of the original 49 establishments in EG 1) will need to be validated (Table 13). This represents only

about 15 percent of all the HACCP plan validations that will occur as a result of the final rule. This number of HACCP plan validations is based on a 50-percent validation rate currently being attained by large establishments, 30-percent rate by small, and a 10-percent rate by very small establishments. These rates are based on information that FSIS obtained from industry sources and in its public meetings related to the proposed rule and Lm risk assessment. Given the high relative numbers of small and very small establishments whose HACCP plans require validation, the total number of establishments affected is 35.

The major impact of the need for HACCP plan validation occurs in establishments already in EG 2 that have an unvalidated PL treatment (60 percent of all expected validation expenses incurred by establishments that already apply a PL treatment). To calculate this impact, establishments in EG 2 are grouped by the same validation rate used for EG 1 establishments above. To the extent that PL treatments are validated by the manufacturer, validation costs would be lower.

Some validation costs are incurred by establishments in EG 2 that are expected to move into EG 1 (20 percent of the large establishments that currently have a PL treatment and 10 percent of those that do not have a PL treatment in EG 2) and some establishments in EG 4 that are expected to move into EG 1 (10 percent of the large and small establishments currently in EG 4).

Table 13. Costs for validation of PL treatments as CCPs in HACCP plans

Item	HACCP Establishment Size Category			
	L	S	VS	Total
	$thousand			
Cost per Plan	20	10	5	
Existing EG 1 HACCP plans				
Number of plans	6	20	17	43
Number of establishments	5	17	14	35
	$thousand			
Cost	$116.6	197.4	85.2	399.2
Establishments in EG 2 moving to EG 1 incurred by establishments that already apply a PL treatment				
Number of plans	13	0	0	13
Number of establishments	10	0	0	10
	$thousand			
Cost	266.5	0	0	266.5
Establishments in EG 4 moving to EG 1				
Number of plans	2	37	0	39
Number of establishments	1	31	0	32
	$thousand			
Cost	31.1	366.6	0	397.7
Cost for existing EG 2 HACCP plans				
Number of plans	17	95	60	171
Number of establishments	14	80	50	143
	$thousand			
Cost	334.9	946.2	300.5	1,581.5
Total Number of HACCP Plan Validations and Cost				
Number of plans	37	151	77	266
Number of establishments	30	127	64	222
	$thousand			
Total Cost, EG 1 and EG 2	749.1	1,510.1	385.7	2,644.8

BILLING CODE 3410–DM–C

Cost to install a post-lethality (PL) treatment. Establishments in EG 1 and about half in EG 2 already have a PL treatment by virtue of being classified in that establishment group. Establishments in EG 4 and those in EG 2 that use an agent or have a process to control *Lm* do not necessarily have a PL treatment. Seven large establishments are expected to move from EG 2 to EG 1 and 1 large establishment moving from EG 4 will need to install PL treatments. 31 small establishments are expected to move from EG 4 to EG 1 and will make similar adjustments.

The Agency received comments to the proposed rule indicated that such investments, like high pressure processing units, cost up to $1.0 million to $1.5 million per unit. FSIS is using $1.5 million and $1.25 million as the expected capital costs of such equipment for large and small establishments, respectively. FSIS received comments regarding per-pound operating expenses for various post-pasteurization processes, but was unable to use this information because of the lack of data on average production per establishment. FSIS assumes annual operating expenses are 10 percent of the initial capital cost.

The changes in the industry (movement among establishment groups) reflected by the installation of post-lethality treatments are given in Table 14.

BILLING CODE 3410–DM–P

Table 14. Costs for post-lethality treatments, equipment and annual operating.

Item	HACCP Establishment Size Category			
	L	S	VS	Total
	$thousand			
PL Equipment Cost per Establishment	1,500.0	1,250.0	NA	NA
Establishments moving from EG 2 to EG 1				
Number of establishments	7	0	0	7
	$thousand			
Equipment cost	11,149.4	0	0	11,149.4
Establishments moving from EG 4 to EG 1				
Number of establishments	1	31	0	32
	$thousand			
Equipment cost	1,897.2	38,536.9	0	40,434.1
Total establishment movements to EG 1				
Number of establishments	8	31	0	39
	$thousand			
Total equipment costs	13,046.6	38,536.9	0	51,583.5
Annual operating costs	1,304.7	3,853.7	0	5,158.4
Total first year costs	14,351.3	42,390.6	0	56,741.9

BILLING CODE 3410–DM–C

Cost to add agent or alter process to inhibit Listeria growth in the final product. One of the major impacts of the rule is that it encourages establishments in EG 4 to move into EG 2 by adding an agent or altering their production processes to inhibit *Lm* growth in the product. Adding such treatments would eliminate the need for more frequent verification testing. It is expected that 25 percent of the large and small establishments in EG 4 will move to EG 2 by doing so—3 large and 77 small establishments. The costs associated with this impact are subject to several factors. They include each establishment's unique situation with respect to product type, facility size, and equipment. Assuming that the cost to add agents or alter a process includes a one-time cost of installing equipment to add agents or alter production processes of $150,000 for a large, $125,000 for a small, and $100,000 for a very small establishment, the initial treatment cost totals $10.1 million. Using an operating cost of 10 percent of the initial cost produces a corresponding annual outlay of about $1 million (Table 15).

Table 15. Costs for Lm growth inhibiting treatments or processes, initial and annual operating.

Item	HACCP Establishment Size Category			
	L	S	VS	Total
	$thousand			
Initial cost per establishment	150.0	125.0	100.0	
	Number of Establishments			
Establishments in EG 4 moving to EG 2	3	77	0	80
	$thousand			
Initial cost	474.3	9,634.2	0	10,108.5
Annual operating costs	47.4	963.4	0	1,010.9
Total costs	521.7	10,597.6	0	11,119.4

Cost of FCS testing for Listeria species. As with the third impact discussed above, the testing provisions of the rule encourage establishments to move from EG 4 into EG 1 and EG 2 (Table 16). These establishments are expected to be mostly small establishments attempting to avoid frequent FCS verification testing requirements for EG 4 establishments and the potential exposure to holding product upon two consecutive positive FCS verification test results. Almost half of the large establishments that were previously in EG 4 are expected to migrate either to EG 1 or to EG 2.

The costs of testing for the remaining 2,518 establishments in EG 3 and EG 4 are based on several assumptions. They include: the actual level of FCS verification testing being conducted at the present time, the percentage of establishments conducting this level of verification testing, the number of production lines by establishment size, and the costs of testing. The assumptions used in this analysis are supported by observations by FSIS inspection personnel and by various recent surveys conducted by FSIS and the industry. For example, in the recent FSIS hotdog and deli-meat survey, about 20 percent of large, 26 percent of small, and about 5 percent of very small establishments stated that they conducted FCS verification testing for *Listeria* spp. The *Lm* growth inhibiting processes and ingredients used in producing these products probably lowers the level of verification testing being conducted by establishments producing other RTE MPPs. Therefore, FSIS believes that the actual proportion of establishments in EG 3 and EG 4 that conduct FCS tests is probably double the proportions reported in the recent hotdog and deli-meat survey for the small and very small establishments. That is, FSIS assumes that the current FCS verification testing levels for large, small, and very small RTE MPP producing establishments are 100 percent, 50 percent, and 10 percent, respectively (*See* middle rows in Table 17).

BILLING CODE 3410–DM–P

Table 16. Number of Federally and State-inspected RTE MPP establishments by establishment group resulting from FCS testing provisions. (Numbers in parenthesis are baseline numbers from Table 7).

Item	HACCP Establishment Size Category			
Establishment Group	L	S	VS	Total
1	25 (9)	55 (24)	16 (16)	95 (49)
2	97 (108)	752 (675)	1514 (1514)	2363 (2297)
3	13 (13)	269 (269)	1581 (1581)	1864 (1864)
4	8 (13)	200 308)	445 (445)	654 (766)
Total establishments	143	1276	3556	4976

Table 17. Assumptions concerning FCS testing in EG3 and EG4

Item	HACCP Establishment Size Category			
Assumption	L	S	VS	Total
Assumed lines/establishment	6	4	2	
Observed average testing frequencies for those that conduct FCS testing (number of times per month)				
EG 3	1	1	1	
EG 4	4	2	1	
Proportion of establishments conducting FCS testing at above frequencies				
EG 3	1.00	0.50	0.10	
EG 4	0.90	0.50	0.10	
Number of tests not conducted by establishments not testing at the above frequencies				
EG 3	0	539	2846	3385
EG 4	20	802	802	1623
Total	20	1341	3647	5007
Cost of testing shortfall by EG 3 and EG 4 at above frequencies, ($35/test):	$thousand			
EG 3	0.0	18.9	99.6	118.5
EG 4	0.7	28.1	28.1	56.8
Total cost for increased FCS testing	0.7	47.0	127.7	175.3

BILLING CODE 3410–DM–C

Cost of Production Adjustments. As was discussed in the PRIA, it is expected that a series of *Lm* contamination events may occur in some establishments. The PRIA expected that most—about 85 percent—of the establishments that obtain one positive FCS test result could remedy the cause of the *Lm* contamination at no additional cost through more stringent sanitation and handling techniques. The remaining 15 percent of establishments are expected to encounter a greater degree of difficulty. Some of these establishments (as discussed in the PRIA) will probably encounter *Lm* contamination problems that could be remedied at a cost of $2,000 per line (these establishments consist of 7 percent of the establishments experiencing at least one positive FCS verification test result); another 7 percent are expected to encounter more serious contamination problems that would need to be remedied by actions costing up to about 1/10 of one percent of gross sales; and a final group made up of 1 percent of the establishments that discover that they have a chronic *Lm* contamination problem and have to cease their RTE MPP production altogether. No comments were received that would either support or refute this scenario or the set of assumptions needed in describing it. Some commented at the May 2001 public meeting that inclusion of these possible eventualities would help complete the analysis. These results are expected to only apply to establishments in EG 4 who face the highest level of FCS verification testing. The underlying assumptions and resultant cost implications are given in Table 18.

Some explanation of the cost estimates of this impact is needed. First, the calculations for cost estimates for minor remedies are the same as in the PRIA. That is, the number of firms in each establishment group is faced with a $2000 per line cost times the number of lines in the establishment for production adjustments. Second, the cost estimates for major repairs are slightly different from those in the PRIA. In the PRIA, the value of shipments for the 1,479 establishments was available and estimated by Census at $25.2 billion for 1999. In the PRIA, this value of shipments was distributed across the 133 large establishments, 840 small ones and 506 very small ones using an average distribution for value of shipments by those size categories of 80-percent (for large), 15-percent (for small), and 5-percent for very small). This average distribution was derived from averages across broad categories of agricultural commodities. A much different distribution of value of production was found in the Fall 2002 FSIS survey of hotdog and deli meat establishments. It found a value of production distribution of 48-percent (large), 48-percent (small), and 4-percent (very small). The final regulatory impact analysis uses a distribution of 65, 35, and 5 in conjunction with the original $25.2 billion for total value of shipments. This calculation produced average per establishment value of shipment estimates of $123 million for large establishments, $9 million for small establishments, and $2 million for very small establishments. This estimate is important because it serves as the basis for calculating the costs to remedy the major cases of *Lm* contamination. As in the PRIA it is expected that a small number of establishments whose contamination problems will be perceived to be prohibitively costly to "fix" and/or not feasible to undertake without complete modernization or renovation. Without making these needed capital improvements, their only option is to either partially or entirely cease RTE MPP production. FSIS expects that up to two small and four very small establishments may be in this situation.

BILLING CODE 3410–DM–P

Table 18. Assumptions about production adjustments to eliminate L. monocytogenes contamination and associated costs

Item	HACCP Establishment Size Category			
	L	S	VS	Total
Lines per establishment	6	4	2	NA
Proportion of establishments with no major L. monocytogenes contamination problems by establishment group:				
EG 3	0.95	0.95	0.9	NA
EG 4	0.85	0.85	0.85	NA
Number of establishments				
EG 3	1	13	158	172
EG 4	1	30	67	98
Total	2	44	225	270
Number of establishments incurring a $2,000 per line costs				
EG 3	0	0	158	158
EG 4	1	14	31	46
Total	1	14	189	204
Number of establishments incurring a major L. monocytogenes contamination problem				
EG 3	0	0	0	0
EG 4	1	14	31	46
Total	1	14	31	46
Number of establishments incurring a severe L. monocytogenes contamination problem				
EG 3	0	0	0	0
EG 4	0	2	4	6
Total	0	2	4	6
Production adjustment Costs	$thousand			
EG 3	0	0	632.4	632.4
EG 4	77.9	238.7	202.4	519.0
Costs of production adjustments	77.9	238.7	834.8	1,151.4

BILLING CODE 3410–DM–C

Costs related to possible hold-and-test actions. Hold-and-test actions are expected to be taken by establishments in EG 4 and to a lesser extent in EG 3. For purposes of this analysis, 50 percent of the EG 3 and 95 percent of the EG 4 establishments that are expected to have some problems with *Lm* contamination are also expected to be faced with one or more hold and test events annually. This calculation suggested that seven small and 79 very small establishments in EG 3 and one large establishment and 29 small and 63 very small establishments in EG 4 are expected to take one or more hold-and-test actions over a typical year. In addition to the number of establishments affected, there are five other factors that affect this cost impact. These are: (1) The amount of production likely affected (based on the number of lines times number of shifts and production per shift estimates); (2) the pounds per pallet that will need to be handled and placed into storage; (3) the average number of days that the product will be held in storage; (4) the number of times per year that a hold-and-test action occurs; and, (5) the cost per day per pallet in handling and storage. Also, the amount of existing available storage will influence any expected burden placed on establishments. The recent FSIS hotdog and deli-meat survey found that up to 40 percent of establishments have sufficient storage to hold product, but for only one to two days of production. Even though this finding only reflects the capacity of hotdog and deli-meat establishments, FSIS does not anticipate any serious problems with establishments finding available storage for holding product under possible increased hold-and-test situations on their premises or at other locations. FSIS bases its estimate for expected industry-wide costs of hold-and-test on parameters stated in Table 19. These costs are intended to include the transportation, handling and storage costs associated with product that has been tested and may or may not prove to be contaminated with *Lm*. For example, the $119,500 cost calculation for hold and test expected to be incurred by very small establishments was made by multiplying the expected number of affected establishments (79) times the number of expected hold and test occurrences per year (3) times the daily cost of holding (5 days times 5.6 pallets times $18 per pallet per day). Similar calculations were made for other affected establishments in the other HACCP establishment size categories and establishment groups. FSIS does not consider that the costs associated with the handling and eventual disposition of contaminated product, including its possible destruction, should be attributed to this final rule. It is believed that this product would have or should have been discovered and appropriately disposed of under current good manufacturing practices had they been followed by the establishment. Also to the extent that some of these products are normally refrigerated, these holding cost estimates would over-estimate the impact on the industry.

Table 19. Cost of hold-and-test actions

Item	HACCP Establishment Size Category			
Assumption	L	S	VS	Total
	Pounds			
Production affected	228,000	28,400	5,600	
	Number of:			
Pallets (1000 lbs. per pallet)	228	28	6	
Average days in storage	5	5	5	
Hold and test frequencies				
EG 3	3	3	3	
EG 4	6	6	6	
	Dollars			
Handling and storage cost per day ($/pallet)	18	18	18	
Handling and storage costs				
	$thousands			
EG 3	20.7	51.7	119.5	191.9
EG 4	144.2	437.9	191.9	774.1
Cost of hold and test	164.9	489.6	311.4	966.0

Analysis of Alternatives

For purposes of the analysis, the expected frequency of FCS verification testing for *Listeria* spp. for establishments in EG 2 is once per line per quarter; for EG 3, at least once per line per month; and for EG 4, once per line per month for very small establishments; semi-monthly for small producing establishments and weekly for high volume producing establishments (4–2–1). These testing frequencies are to be considered minimum expected levels for the purposes of estimating costs and benefits. Conditions may warrant a higher frequency of FCS verification testing to assure FSIS that establishments' sanitation or prerequisite plans are adequately addressing the risk of possible contamination in its products. As an additional precaution, FSIS is requiring that after a second positive *Listeria* spp. FCS test result in an EG 4 establishment, hold and test actions are taken until such time that FSIS is assured that this action is no longer needed.

The FSIS *Lm* Risk Assessment found an increase in median lives saved as FCS verification testing frequencies increase relative to the baseline. The minimum FCS verification testing frequency for EG 4 (4–2–1) results in 25 deaths averted if there is 100 percent adoption of this testing frequency by all establishments producing deli meats.

An alternative FCS verification testing frequency could be 40–20–10 for EG 4. In this case, the reduction in human health risk increases to 89 deaths averted, given 100 percent adoption. At an extremely high level of testing, such as 60–60–60 (for either FCS verification testing for *Listeria* spp. or product testing for *Lm*), 153 deaths are averted given 100 percent adoption. Also, at these high levels of FCS verification testing, hold and test protocols were shown to reduce the level of *Lm* contamination at retail.

Extremely high FCS verification testing levels may not be required to assure adequate sanitation. Nor are they necessarily effective from an economic perspective. Costly hold and test actions increase with FCS verification testing frequency. As such costs increase, establishments producing RTE MPPs, especially small and very small establishments, may eliminate product lines or cease production entirely. FSIS recognizes, however, that FCS verification testing frequencies higher than 4–2–1 may be appropriate for establishments with a history of poor sanitation controls or evidence of producing adulterated product.

Another concern about high FCS verification testing frequencies is the likelihood that many establishments that produce RTE MPPs using traditional methods will no longer produce such products. To the extent that this reduces the amount of adulterated product, this rule and its emphasis on FCS verification testing is appropriate. It may be inappropriate for any product that FCS testing for *Listeria* species is not a reliable indicator for *Lm* product contamination. FSIS believes that its establishment categorization in this final rule will place only those products in EG 4 where intense sanitation and verification testing is most appropriate. However, extremely high verification testing frequencies in most cases may be unnecessary and burdensome.

The risk assessment clearly shows that a combination of post-lethality treatment or *Lm* growth inhibition along with sanitation and FCS verification testing and other measures is more effective than a "sanitation coupled with FCS verification testing only" strategy. This result also reinforces the observed industry practice of maintaining a series of adequate precautions throughout slaughter and processing, and of not exclusively relying on verification of sanitation through FCS testing alone to assure that products are not adulterated. FCS verification testing of sanitation procedures for *Listeria* species can compliment these other measures, *e.g.* post processing pasteurization, the addition of *Lm* growth inhibiting packaging. To the extent that establishments take a series of steps to address their possible *Lm* contamination, the need for higher FCS verification testing frequencies, and its impact of inspection personnel to review these data, is reduced.

Summary of Direct Industry Costs

The PRIA identified three major possible industry-wide impacts from mandatory FCS verification testing: HACCP plan modification costs ($1.28 million); direct testing costs ($1.75 million); and, production adjustments ($2.5 million). The total first-year cost of these impacts was $5.53 million—$3.8 million in one-time outlays and $1.75 million in recurring annual costs associated with testing.

The Final Regulatory Impact Analysis (FRIA) reflects many comments received in the public comment period. In addition to the impacts identified in the PRIA, the FRIA estimates (1) the cost of PL treatments (initial and annual operating); (2) the cost of using an agent or process to inhibit *Lm* growth (initial and annual operating); and, (3) the costs of holding product while awaiting confirmation of FCS verification testing.

The validation of PL treatments and related HACCP plan modifications results in a one-time cost of $2.6 million. The estimated cost in the FRIA is higher than that in the PRIA due to an increase in the number of establishments affected. The FRIA estimate may be conservative as it does not take into account the use of validation studies conducted by PL equipment manufacturers. Direct testing costs are substantially lower than estimated in the PRIA ($175,260 versus $1.75 million) because the expected movement of establishments out of EG 4 and into the other establishment groups where higher FCS verification testing is not expected. Production adjustments are estimated at $1.15 million in one-time costs in the FRIA compared to $2.5 million in the PRIA. The difference is due mainly to fewer expected cases where establishments are not able to overcome their *Lm* contamination problem. More establishments adopt PL treatments and move into EG 1 or EG 2. The total of the two, one-time cost components (production adjustments and use of PL treatments) is the same as that estimated in the PRIA ($3.8 million as opposed to $3.75 million estimated in the PRIA). Verification testing costs, as noted above, are substantially lower than that estimated in the PRIA.

The additional costs associated with the installation of PL treatments and/or altering their production to incorporate an agent or process to inhibit *Lm* growth introduces potentially large cost outlays, especially for the initial, one-time investments in plant and equipment (Table 20). The initial industry-wide, one-time cost outlays for equipment associated with production adjustments and PL treatments are expected to be as high as $51.6 and $10.1 million, respectively. The annual operating (recurring) costs of $5.2 and $1 million, respectively, make first-year costs for these two technologies, $56.7 and $11.1 million, respectively.

Table 20. Total Expected Industry-wide Costs

Item	HACCP Establishment Size Category			Total
	L	S	VS	
	$thousand			
PL validation	749.1	1,510.1	385.7	2,644.8
PL Equipment & operations	14,351.3	42,390.6	0	56,741.
Growth inhibiting agent or process	521.7	10,597.6	0	11,119.4
FCS testing	.7	46.9	127.7	175.3
Production adjustments	77.9	238.7	834.8	1,151.4
Product handling and storage	165.0	489.6	311.4	966.0
Total Costs	15,865.7	55,273.5	1,659.5	72,798.7

Converting initial costs into an annual equivalent cost of capital recovery provides a more accurate measure of economic impacts.[8] Using a 7-percent discount rate over ten years results in annualized cost of $9.3 million for PL validation, installation, agent and/or process alteration cost, and production adjustments. The annual operating (recurring) costs are estimated at $7.3 million. Combining these two estimates produces a total annual cost of the final rule of $16.6 million (bottom of Table 21).

Table 21. Total Annualized Industry-wide Cost Impact, by establishment size.

Item	HACCP Establishment Size Category			
	L	S	VS	Total
	$thousand			
Initial	14,347.9	49,919.9	1,220.5	65,488.2
Recurring	1,517.8	5,353.5	439.1	7,310.4
Total	15,865.6	55,273.5	1,659.5	72,798.6
	22%	76%	2%	100%
Annualized Cost	10 year, 7-percent			
Initial	2,042.8	7,107.5	173.8	9,324.0
Recurring	1,517.8	5,353.6	439.1	7,310.4
Total	3,560.6	12,461.1	612.8	16,634.5
	21%	75%	4%	100%

Possible Indirect and Unintended Cost Impacts

The focus of the cost discussion thus far was mainly on industry-wide direct compliance costs: These costs, on an annual basis, were estimated at $16.6 million, roughly one-half of one percent of the total annual value of industry sales ($16.6 million divided by $25.2 billion). In addition, some discussion was made of the possible impacts that the final rule may have on lowering product quality, reducing current FCS testing frequencies in some establishments, and forcing some establishments to exit the industry. However, these impacts were not quantified. Two other possible indirect cost impacts are on consumers and other sectors of the economy.

No market product quantity and price data are available to calculate the possible consumer price implications brought about by the higher compliance costs identified in this analysis. This information, plus an estimation of any reduction in market supplies, could be used to calculate the social costs of shifts in supply and demand in a consumer- and producer-surplus framework. Also, a complicating factor in estimating possible market supply reductions is to what extent imported product could be substituted for any U.S. RTE MPP production cutback. Without such information, one can only say that higher industry compliance

[8] Lynn E. Bussey, *The Economic Analysis of Industrial Projects*, Engelwood Cliffs, New Jersey, 1978.

costs and lower market supplies would be expected to raise consumer prices to some extent. From the information provided in this analysis (the expected small cost impacts relative to total value of production and the likely small quantity cut-backs), it is expected that these impacts would be minimal.

A related issue is the possible impact on other sectors of the economy. Census data show that swine, beef, dairy, and poultry industries supply significant amounts of raw product to the RTE MPP industry. Because, however, the quantity effect is expected to be minimal, these upstream suppliers of raw material are not expected to be significantly affected by the final rule.

Analysis of Benefits

The analysis of benefits resulting from the final rule examines the reduction in human health risk (deaths and illnesses caused by listeriosis) from actions taken as a result of this final rule by RTE MPP establishments in only one product group: deli meats (primarily sliced luncheon meats). This analysis of benefits thus differs from that in the PRIA which examined the reduction in human health risk from all RTE MPPs.

FSIS is focusing on deli products for several reasons. First, the FDA–FSIS risk assessment identified this product group as having the highest risk of all food classes and the cause of a large share of listeriosis deaths and illnesses. Second, the FSIS *Lm* Risk Assessment, when calibrated to a revised version of FDA–FSIS risk assessment, tied risk mitigation actions at deli-meat producing establishments to potentially lower rates of listeriosis death and illnesses. FSIS plans to modify the model to capture the dynamics of *Lm* contamination and containment in other RTE MPP products, such as hotdogs, along with the impact of production volume. Third, the FSIS *Lm* Risk Assessment, having been presented to the public for comment, has been revised to the extent possible at this time.

The analysis of benefits uses the FSIS *Lm* Risk Assessment to evaluate the human health risk reduction effects of sanitation coupled with FCS verification testing, the use of growth inhibiting packaging (GIP); and the use of PL treatments. The likely reduction in listeriosis deaths from a 100-percent adoption of these practices and treatments by the industry is given in Table 22. FSIS is reporting three values for the possible benefits derived from this rule: The median, the 5th percentile, and the 95th percentile for each scenario (baseline, sanitation/FCS verification testing, *Lm* growth-inhibiting packaging (GIP) and post-lethality processing (PP) + GIP). This range of values represents the uncertainty in the true number of averted number of deaths per year. The reported results imply 90 percent certainty that the true value lies between the 5th and 95th percentiles. Each uncertainty distribution is the result of three hundred computer simulations, each simulation consisting of 100,000 iterations, of the FDA–FSIS risk ranking model. The risk characterization portion of that model comprises 4,000 combinations of the exposure distributions for the 23 different food groups in the FDA–FSIS risk ranking model. The median reports the mid-point value of deaths averted from these multiple computer simulations for each scenario. The median is reported because it is the preferred measure of central tendency in the FDA–FSIS risk ranking. Furthermore, the distribution of results suggests that the mean, as an alternative measure of central tendency, is less informative about the shape of the distribution because of the influence of outliers in its calculation. Illnesses are estimated using the standard .20 case-fatality rate commonly reported in the literature.

Table 22. Incremental Reductions in Deaths Due to Various Interventions (assuming 100% industry-wide adoption)

	Averted Deaths			Averted Illnesses		
Scenario	Median	5%	95%	Median	5%	95%
FCS testing /1	25 (24)	8 (8)	25 (24)	125 (120)	42 (40)	125 (120)
GIP	141 (135)	48 (45)	165 (158)	707 (675)	240 (225)	823 (790)
PP & GIP	238 (227)	77 (72)	272 (261)	1188 (1135)	384 (360)	1360 (1305)

/1 FCS testing at a 4-2-1 rate.

/2 Numbers in parentheses exclude reductions in neonate deaths.

The greatest reduction in listeriosis deaths and illnesses would occur if all establishments used both PP and GIP. However, 100 percent adoption is not possible for a variety of reasons, including technical—not all products are amenable to the use of PL or GIP—and economic—the costs are prohibitive in relation to the value of the product.

The analysis of costs described movements among establishment groups that are likely to occur as a result of the final rule. These movements are the basis for estimating the human health benefits of the final rule. Establishment group net movements are placed on a percentage basis of establishments in each size class (Table 23). The absolute changes in establishment numbers are converted into percentage increases by dividing the number establishments estimated to adopt one or more measures by the total number of establishments in that size class. For example, 2 of the 42 large establishments producing deli meats (4.8 percent) are estimated to adopt PL and GIP measures. Next, the percentage change in establishments is weighted by the relative volume of deli meats produced by that size class. The two large establishments are estimated to account for 2.3 percent of deli-meat production (4.8 times 0.48). The summation of these weighted percentages produces the percentage increase in that technology which is adopted as a result of the final rule. Thus, deli-meat producing establishments adopting PL and GIP represent a 5.4-percent increase in the amount of deli-meat production that is produced using this technology. Likewise, the percent increase in the amount of production using GIP and FCS sanitation/verification testing is 8.9 and 13.3 percent, respectively.

Table 23. Number of establishments adopting various interventions

Item	HACCP Establishment Size Category			Average
	L	S	VS	
Product Volume Weights	0.48	0.48	0.04	
Deli-meat producing stab.	42	311	340	
Mitigation Measure	Number of Establishments			
Establishments adopting PL and GIP	2	20	0	
	Percent			
Establishments	4.8	6.4	0.0	
Product	2.3	3.1	0.0	5.4
Mitigation Measure	Number of Establishments			
Establishments adopting GIP	1	50	0	
	Percent			
Establishments	2.4	16.1	0.0	
Product	1.2	7.7	0.0	8.9
Mitigation Measure	Number of Establishments			
Establishments adopting FCS Testing at a 4-2-1 rate	0	66	260	
	Percent			
Establishments	0.0	21.2	76.5	
Product	0.0	10.2	3.1	13.3

The results in Tables 22 and 23 are used to estimate the possible reduction in listeriosis deaths that may be attributed to actions taken be deli-meat producing establishments as a result of the final rule (Table 24).

This analysis excludes neonate deaths estimated by the FSIS risk assessment because of concerns about using the standard values for a statistical life, which are derived from adult lives. Of course, it is obvious that averting such neonate losses is a potentially significant benefit. However, excluding these losses does not substantially affect the conclusions of this analysis.

Calculations combining information from Tables 22 and 23 are fairly straightforward: for example, the 13.3 percent increase in adoption rates of sanitation coupled with FCS verification testing translates into 3.1 fewer listeriosis deaths at the median (0.133 from Table 23 times 24 from Table 22); 1.0 fewer at the 5th percentile (0.133 × 8.0); and, 3.1 fewer at the 95th percentile (0.133 × 24). Similar calculations for the other two mitigation measures result in a total reduction of 27.3 at the median; 8.9 at the 5th percentile; and, 31.2 at the 95th percentile. The corresponding reductions in illnesses are 136.7 at the median, 44.6 at the 5th percentile, and 156.0 at the 95th percentile, respectively.

Table 24. Reduction in listeriosis deaths due to various interventions

Interventions	Averted Deaths		
	Median	5th percentile	95th percentile
FCS Testing (4-2-1)	3.1	1.0	3.2
GIP	12.0	4.0	14.0
PL & GIP	12.2	3.9	14.0
Total Reduction	27.3	8.9	31.2

The Economic Research Service of USDA presented a method for estimating the human health benefits of reduced listeriosis at a public meeting on the proposed rule held in May 2001. To estimate the benefits, it was assumed that 5 percent of the cases were moderate, and that moderate cases resulted in hospital costs of $10,300 per case. The remaining 95 percent of the illness were severe, resulting in hospital costs of $28,300 per case.[9] Using these assumptions and excluding the loss in productivity of those affected and any pain and suffering, the benefits of the reduction in illness-related losses due to the final rule are estimated to be $3.7 million at the median (0.05 × 136.7 × $10,300) + (0.95 × 136.7 × $28,300)) and $1.2 million at the 5th and $4.3 million at the 95th percentile.

ERS estimated the value of statistical life at $4.8 million[7] as a proxy for the cost of one fatality. Based on this estimate, the annual human health benefits from the implementation of the final rule are $134.9 million at the median (the $3.7 million above plus 27.3 × $4.8 million) and $44.0 million at the 5th percentile and $154.0 million at the 95th percentile.

Given the limitations in data and the output of the risk assessment dealing only with deli meats and as per the discussion found earlier concerning the estimates of health consequences, FSIS believes that this estimate may be overstated by as much as 50 percent. If so, the adjusted annual net benefits then become $50.8 million, $5.4 million and $60.4 million at the median, 5th and 95th percentile levels, respectively (Table 25). It appears that a downward adjustment in total benefits of 85 percent would be necessary to lower net benefits to near zero.

Table 25. Summary of Annual Total and Net Benefits

Item	No adjustment	Benefits reduced 50 percent	Benefits at Breakeven (15%)
	$million		
Total Benefits			
Median	134.9	67.5	20.2
5th percentile	44.0	22.0	6.6
95th percentile	154.0	77.0	23.1
Net Benefits			
Median	118.3	50.8	3.6
5th percentile	27.4	5.4	-10.0
95th percentile	137.4	60.4	6.5

Net benefits hold industry-wide compliance cost of this regulation constant at $16.6 million.

Compliance With Regulatory Flexibility Act of 1996

The Administrator has determined that for the purposes of the Regulatory Flexibility Act (5 U.S.C. 601–612), this rule will have a significant economic impact on a substantial number of small entities. As discussed above, FSIS estimates that the *Lm* sanitation coupled with FCS verification testing provisions of this final rule may result in annual costs to small and very small producers of post-lethality exposed RTE MPPs of $12.5 and $0.6 million, respectively. These establishments incur about 79 percent of the total industry-wide costs of compliance with the sanitation coupled with FCS verification testing provisions of this final rule.

The Small Business Regulatory Enforcement Fairness Act of 1996 (Pub. L. 104–121) requires, among other things, that for each rule or group of related rules for which an agency is required to prepare a final regulatory flexibility analysis under section 604 of title 5, United States Code, the agency must publish one or more guides to assist small entities in complying with the rule, and must designate such publications as "small entity compliance guides". The guides must explain the actions a small entity is required to take to comply with a rule or group of rules. FSIS is developing guidance to assist small and very small establishments in fulfilling their responsibilities under the final rule. The guides will include instructions on how establishments that produce post-lethality exposed RTE MPPs can conduct sanitation coupled with FCS and product verification testing. Establishments that wish to use the guides may incorporate their features into their HACCP plans, Sanitation SOPs or other prerequisite programs. Because FSIS is basing its guidance on existing research and industry practices that are known to be effective, the Agency also will consider the processing instructions to be already validated. That is, an establishment may follow the guidance without contracting for or conducting additional validation of the content of the materials.

FSIS is examining other options to minimize the potential negative economic effects of these proposed regulations on small businesses, including encouraging research that would facilitate validation of pathogen lethality in many products, especially those produced by traditional methods by small and very small establishments.

Types of Entities and Production Affected by the Final Regulations. The preliminary RIA found that small and very small establishments made up about 91 percent of the number of establishments in the U.S. RTE MPP industry and were expected to incur up to 69 percent of the cost of complying with the requirements of the proposed rule. The FRIA finds that small and very small establishments make up about 97 percent of the number of establishments in the industry and are expected to incur nearly 80 percent of total cost impact on the industry. As was also stated in the FRIA, the final rule only involves that part of the original proposal dealing with FCS verification testing for *Lm* or indicator organism and also uses a more accurate baseline for the number of establishments affected by the final rule.

An important note to consider throughout this analysis is that much of the projected impacts originate from expected movements of establishments from one establishment group to another. As was stated in the

[9] Stephen Crutchfield, "The Benefits of Reducing Listeria in Ready to Eat Products." 2001. Presented t public meeting, "Performance Standards for the roduction of processed Meat and Poultry Products," May 9–10, 2001. FSIS–USDA Washington, D.C. Roberts, Tanya, and Robert Pinner. Economic Impact of Disease Caused by Listeria monocytogenes." In Miller, AJ, Smith JL, and Somkuti GA, (Eds.) *Foodborne Listeriosis.* Amsterdam, the Netherlands: Elsevier Science Publishing Co., 1990, pp. 137–144.

preliminary RIA, "mandatory *Listeria* testing is the most difficult provision in the proposed rule to analyze because of the uncertainty of current practices and how establishments will react to the proposed rule. Major uncertainties include: the degree to which firms will switch to a *Listeria*-related CCP in their HACCP plan, the degree to which firms will be able to resolve their *Listeria*-related problems if they present themselves, and the degree to which they must increase their testing." This problem is further compounded in this analysis because the final rule is not limited to whether establishments either elect to incorporate a *Lm*-related CCP in their HACCP plan or face mandatory testing. In this analysis, it is possible for establishments to address possible *Lm* contamination in their operations through a variety of methods.

A large share of the cost impact is on small establishments, which are expected to absorb nearly 75 percent of the total industry-wide cost impact (Tables 26 and 27). These establishments have the same incentives to move to new post-pasteurization technologies as do very small establishments, but their production volumes more easily justify the associated high capital and recurring expenditures. Very small establishments will likely have to increase sanitation coupled with FCS verification testing to comply with this final rule. Large establishments are likely to complete the process of adopting new technologies. The expected impacts on large, small, and very small establishments are discussed below.

Large Establishments

As discussed in the "Baseline" section of this analysis, most (131 out of 144 large establishments) already fall into either establishment group 1, 2 or 3. This number is expected to increase by 5 establishments as a result of the final rule, leaving only 8 establishments in the establishment group 4: those establishments required to conduct more intense sanitation coupled with FCS *L. spp.* verification testing than establishments producing product in the other establishment groups. Many of these firms already employ post-pasteurization technologies, but need them validated to comply with the final rule. In fact, six of the existing establishments in EG 1 and four of the establishments from EG 2 already employ the technology, but simply have not validated their processes. It is expected that total validation costs will run about $749,000 in first-year costs for these establishments.

The remaining establishments are likely to have high enough product volume levels to justify the acquisition of new post-pasteurization technologies and/or to alter product formulations and packaging. The remaining eight establishments (seven of the 10 establishments from EG 2 (or 10 percent of the establishments in EG 2 that do not apply a post-pasteurization step)); and one from EG 4 (or 10 percent of the establishments in EG 4) all are expected to need post-pasteurization equipment and have their processes validated. The resulting large initial cost outlays plus the estimated recurring annual operating costs are expected to total $14.3 million in first-year costs. This cost represents about 90 percent of all the costs that are expected to be incurred by large establishments as a result of this final rule. The remaining costs are incurred by those establishments electing to add an inhibiting agent or process in their production or to a lesser degree, as a result of sanitation coupled with FCS verification testing and possible subsequent actions related to hold and test and finding remedies to possible persistent *Lm* contamination problems.

Small Establishments

It is estimated that there are 1,276 small establishments producing RTE MPPs. FSIS estimates that 108 small establishments will migrate to other establishment categories as a result of the final rule. This is a costly undertaking, especially for those establishments that elect to migrate into EG 1. Due to the high cost of both technologies (post-lethality processing and adding an agent or process to the product) and because their products must conform to both process adjustments, it is expected that only 31 establishments (or 10 percent of the small establishments that were formally in EG 4) migrate to EG 1 as a result of the final rule. All movement involves the purchase and use of new technology which is expected to cost these establishments over $42 million. About twice the number of establishments that is expected to migrate to EG 1 is expected to migrate to EG 2. This move is less costly and it is expected that more RTE MPPs lead themselves to the addition of an inhibiting agent or process. These 77 establishments are expected to incur $10.6 million in first-year, total direct and recurring costs. All of the 108 establishments are expected to migrate from EG 4.

Very Small Establishments

It is estimated that there are 3,556 very small establishments producing RTE MPPs. The preliminary RIA had an estimate of only 524 establishments, acknowledging that that estimate severely underestimated the true number of very small establishments. Due to the combination of high costs and technical difficulties faced by very small establishments, FSIS projects that no very small establishments will shift into a different establishment group. Consequently, FSIS does not expect that very small establishments will incur any costs associated with the adoption of post lethality treatment methods or by incorporating an inhibiting agent or process in their production. Instead, most of the entire cost impact of this final rule on very small establishments is expected to originate from sanitation coupled with FCS verification testing and the possible production adjustments and additional handling and storage associated with increased testing and the higher likelihood of incurring *Listeria* species positive FCS test results. A small amount of costs are expected to be incurred by those very small establishments that currently employ un-validated post-lethality processing technologies.

Summary

Small establishments make up 26 percent of the establishments, yet are expected to incur up to 75 percent of the aggregate cost burden. Much of these expected costs are in large capital expenditures in post lethality processing equipment and in changing their production process to incorporate *Lm* growth inhibiting agents or processes. This cost impact would be reduced to the extent that these cost estimates over-estimate the actual costs of acquiring these technologies or over-estimate the establishment movements. It is unlikely that actual cost impacts would exceed those estimated in this analysis. Very small establishments make up 71 percent of the number of establishments in the industry and yet are expected to incur only 4 percent of the total costs of this final rule. This estimate may under-estimate their exposure to cost increases related to FCS testing. Thus, it is unlikely that actual cost impacts would be lower than those estimated in this analysis. The estimates for large establishments are highly contingent on their movement into EG1 and EG2. To the degree that actual movements into these establishment groups occur, the estimates in this analysis should reflect these expected cost outlays.

BILLING CODE 3410–DM–P

Table 26. Potential First-Year Total Direct and Recurring Cost Impacts Across HACCP Establishment Size Categories.

Cost Component	HACCP Establishment Size Category			
	L	S	VS	Total 2/
	$thousand			
PL Validation	749.0	1,510.1	385.7	2,644.8
PL Installation	14,351.3	42,390.6	0	56,741.9
Growth Inhibitor	521.7	10,597.6	0	11,119.3
FCS testing	0	46.8	127.5	175.3
Production Adjustments	77.9	238.7	834.8	1,151.4
Handling & Storage	165.0	489.6	311.4	966.0
Total Costs Above	15,865.6	55,273.5	1,659.5	72,798.6
Total Costs broken into one-time, initial year costs and recurring costs.				
One-time, initial year	14,347.9	49,919.9	1,220.4	65,488.2
Recurring	1,517.8	5,353.6	439.0	7,310.4

Table 27. Estimated Total Cost Impact of Final Rule, Annualized.

Annualized Cost	10 year, 7-percent			
	HACCP Establishment Size Category			
	L	S	VS	Total
	$thousand			
One-time costs	2,042.8	7,107.5	173.8	9,324.0
Recurring	1,517.8	5,353.6	439.1	7,310.4
Total	3,560.6	12,461.1	612.8	16,634.5
	Percent			
Total Costs	21	75	4	100
	Percent			
Establishments	3	26	71	100

[FR Doc. 03–14173 Filed 6–5–03; 8:45 am]
BILLING CODE 3410–DM–P

MSDS

PURAC

UNCONTROLLED DOCUMENT

Product data

Rev.No3/3002

PURASAL®S/SP 60

Description

PURASAL S/SP is the sodium salt of natural L(+) lactic acid, produced by fermentation of sugar. It has a mild saline taste, antimicrobial properties and is neutral by pH.
PURASAL S/SP is the ultra pure food grade L-sodium lactate.

Specification

Product	L-Sodium lactate
Form	Liquid
Color fresh	max. 25 apha
Assay	58.8-61.2% w/w
Assay sodium	12.1-12.6% w/w
Stereochemical purity (L-isomer)	min. 95%
pH (16.7 g product + 83.3 g water)	6.0-7.5
Density at 20°C	1.32-1.34 g/ml
Sodium	12.0-12.5%
Calcium	max. 20 ppm
Chloride	max. 50 ppm
Sulphate	max. 20 ppm
Iron	max. 10 ppm
Heavy metals total	max. 5 ppm

Physical-chemical properties

Molecular formula	$CH_3CHOHCOONa$
Molecular weight	112 (anhydrous)
Chemical name	Sodium-L-2-hydroxy-propionate

Registration

CAS number	72-17-3
EEC additive number	E 325
USA	GRAS
Complies with	FCC, EUSFA*

*) Complies with EUSFA when the pH of an aqueous solution of 1 ml product in 5 ml water is 6.5-7.5

Packaging

PURASAL S/SP is supplied in 210 L (55 gallon) polyethylene drums (275 kg, 606 lbs), 1000 L (264 gallon) semi-bulk containers (1315 kg, 2899 lbs) and bulk containers.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained therein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further Information:

http://www.purac.com/

PURAC

UNCONTROLLED DOCUMENT

SAFETY DATA SHEET

Sodium-L- Lactate, PURASAL®S

REVISION DATE 23/09/03
REF. SD0130/2003-01

1. IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND THE COMPANY / UNDERTAKING

Product name	Sodium-L-Lactate, PURASAL® S	
Product code	3001-3008, 3501-3608	
Supplier	PURAC America, Inc. 111 Barclay Blvd. Lincolnshire, IL 60069 USA	PBR sinteses Praça Pio X, 15, 9° andar CEP 20.040-020 Rio de Janiero Brazil
Telephone	(847) 634 6330	++55 21 203 2191
Fax	(847) 634 1992	++55 21 263 9288
Emergency Telephone:	(800) 424 9300	++55 21 263 7292
Supplier	PURAC biochem Arkelsedijk 46 NL-4206 AC Gorinchem The Netherlands	Purac bioquimica Gran Vial 19-25 E 08160 Montmelo Barcelona Spain
Telephone	++31 (0) 183 695695	++34 93 572 1016
Fax	++31 (0) 183 695604	++34 93 568 3955
Emergency Telephone	++31 (0) 183 695695	++34 93 568 6300 (Ext 222)

2. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical name of the substance			Sodium-L-(-)-2-hydroxy propionate aqueous solution.
Synonyms			Sodium Lactate, Sodium-L(-)-2-hydroxy propionate
CAS-No.	867-56-1	EC-No	212-762-3

3. HAZARDS IDENTIFICATION

Most important hazards	May cause eye irritation with susceptible persons.

4. FIRST AID MEASURES

General advice	Show this safety data sheet to the doctor in attendance.
Inhalation	Move to fresh air.
Skin contact	Wash off with plenty of water.
Eye contact	Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion	Drink plenty of water.
Major effects of exposure	May cause eye irritation with susceptible persons.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Water, carbon dioxide (CO2), foam.
Extinguishing media which must not be used for safety reasons	None.
Specific hazards	Burning produces irritant fumes.
Special protective equipment for firefighters	None.
Specific methods	Standard procedure for chemical fires.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Avoid contact with eyes. Use personal protective equipment.
Environmental precautions	No special environmental precautions required.
Methods for cleaning up	Flush with water.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Sodium-L- Lactate, PURASAL®S

REVISION DATE 23/09/03
REF. SD0130/2003-01

7. HANDLING AND STORAGE

Handling	
Technical measures/Precautions	No special technical protective measures required.
Safe handling advice	Handle in accordance with good industrial hygiene and safety practice.
Storage	
Technical measures/ Storage conditions	Keep tightly closed in a dry place. Avoid long storage times.
Packaging material	Steel and plastic packages.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure	Insure adequate ventilation, especially in confined areas.
Control parameters	None.
Personal protection equipment	
Respiratory protection	Not applicable.
Hand protection	Not applicable.
Eye protection	Safety glasses.
Skin and body protection	Not applicable.
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	aqueous solution
Color	light yellow
Odor	slight / none
pH	6.5 - 8.5 (10 - 60% aqueous solution) @ 77°F (25°C)
Molecular Weight	not applicable
Boiling point/range	221°F (105°C) (50% solution), 230°F (110°C) (60% solution)
Decomposition temperature	>392°F(200°C)
Autoignition temperature	not applicable
Flash point	not applicable
Explosion limits	not applicable
Density	1320 - 1340kg/m^3 @ 68°F (20°C) (60 % solution)
Solubility	Water solubility: completely soluble
Viscosity	80 - 160 mPa.s @ 68°F (20°C)

10. STABILITY AND REACTIVITY

Stability	Stable at normal conditions.
Materials to avoid	None.
Hazardous decomposition Products	Carbon oxides.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded, or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Sodium-L- Lactate, PURASAL®S

REVISION DATE 23/09/03
REF. SD0130/2003-01

11. TOXICOLOGICAL INFORMATION

Acute toxicity	Health injuries are not known or expected under normal use. LD50/intraperitoneal/rat = 2000 mg/kg LD50/oral/rat = 2000 mg/kg.
Local effects	May cause eye irritation with susceptible persons.
Specific effects	Based on tests with L-lactic acid and its salts, there is no evidence to suggest carcinogenic nor mutagenic properties from lactic acid itself nor from the lactate portion of its metal salts.
Further information	Natural product in the body.

12. ECOLOGICAL INFORMATION

Mobility	Completely soluble in water.
Persistence / degradability	Product is a salt of lactic acid which is readily biodegradable.
Bioaccumulation	Unlikely.
Ecotoxicity	Ecological injuries are not known or expected under normal use.(No effect on Daphnia @ 10g/l.)

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products	Can be disposed as waste water, when in compliance with local regulations. Can be landfilled or incinerated, when in compliance with local regulations.
Contaminated packaging	Clean container with water. Empty containers should be taken for local recycling, recovery or waste disposal.

14. TRANSPORT INFORMATION

Not classified as dangerous in the meaning of transport regulations.

15. REGULATORY INFORMATION

US Regulations	TSCA Inventory Status: Y (Sodium Lactate) SARA III: N California Proposition 65: N Carcinogenic status: OSHA: N. NTP: N, IARC: N FDA: GRAS
# EU Status	Not a hazardous substance or preparation according to EC-directives 67/548/EEC or 99/45/EC. EU Food additive (Sodium Lactate E325)

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Sodium-L- Lactate, PURASAL®S

REVISION DATE 23/09/03
REF. SD0130/2003-01

16. OTHER INFORMATION

CAS-No. 72-17-3 (general) **EC-No** 200-772-0 (general)

NFPA Ratings (Scale 0-4) 0(health)-0(flammability)-0(reactivity)
HMIS Rating 0(health)-0(flammability)-0(reactivity)-A (protective equipment)

Further information on the safety assessment of sodium lactate and lactic acid can be obtained in a CFTA Report of June 6th 1997.

# indicates updated section.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PRODUCT SPECIFICATIONS

Product: **Ultra-Pure SL-75 (60%)**

Contents: **Sodium Lactate** ($CH_3CHOHCOONa$)

USA:	**GRAS** (21CFR - 184.1768)
EEC Additive Number:	**E:325**
CAS Number:	**72-17-3**

Description:

Ultra-Pure SL-75 is a mild-flavored sodium salt of natural lactic acid that offers unique antimicrobial properties. Natural lactic acid is produced from the fermentation of sugar. The exclusive Ultra-Pure process greatly reduces the objectionable flavors or aftertaste common to most commercial lactates. The result is a clean-flavored and pH consistent food grade L-sodium lactate.

Specifications:

Form	Aqueous solution
Flavor	Gentle saline profile
Appearance	Clear to slightly amber
Color	50 apha max
Density at 20° C	1.31 – 1.34 g/ml
Assay, sodium lactate	58% - 62%
pH	6.0 – 8.5
Sodium	11.9% - 12.9%
Chloride	50 ppm max
Sulfate	20 ppm max
Heavy Metals, as Pb	5 ppm max

Government Regulations & Labeling:

Meets FCC, is Kosher Certified and is affirmed GRAS by the FDA. USDA/FSIS permits sodium lactate to be used up to 4.8% in both standard and non-specific meat and poultry products. It should be listed on the product ingredient statement as "sodium lactate".

Packaging:

55-lb (25 kg) plastic pails, 600-lb (272.1 kg) plastic drums and 2875-lb (1303.9 kg) bulk totes.

Storage:

Hold in dry room at room temperature.

This information is presented for your consideration in the belief that it is accurate and reliable, however, no warranty either expressed or implied is made and no freedom from liability from patents, trademarks, or other limitations should be inferred. The data listed are average values only, and are not to be considered as guarantees expressed or implied, nor as a condition of sale. Typical analysis data which should not be construed as being specifications fall within the range of standard manufacturing practices. Product as received will vary within this range. TRUMARK INC. has no control over the transportation, storage, handling or use of the product made by purchasers or others we cannot be responsible for damages resulting from the use of such product. TRUMARK, INC. warrants only that when shipped from its facility the product will meet published specifications. No warranty of merchantability or fitness for a particular purpose is given or implied.

01.01.03

TRUMARK INC

830 EAST ELIZABETH AVENUE ■ LINDEN, N.J. 07036 USA ■ (908) 486-5900 ■ (800) 752-7877 ■ FAX (908) 486-5005 ■ EMAIL

TECHNICAL BULLETIN

MATERIAL SAFETY DATA SHEET

ULTRA-PURE SL-75

Quick Identifier: 60% Sodium Lactate
Revision Date: 22 October 2002

GENERAL INFORMATION

Manufacturer's Name:	Trumark Inc.
Address:	830 E. Elizabeth Avenue Linden, NJ 07036 USA
Telephone Number:	908-486-5900 or 800-752-7877 (in the USA)
Fax Number:	908-486-5905
Emergency Number:	Chemtrec (800-424-9300 in the USA) or 703-527-3887

HAZARDOUS INGREDIENTS/ IDENTITY

Emergency Overview:	No health concerns are known or expected under normal use.
CAS Number:	Sodium Lactate 60% (72-17-3) Water 40% (7732-18-5)
OSHA/PEL:	N/A
ACGIH/TLV:	N/A

HEALTH HAZARDS

Inhalation:	None known.
Skin:	Possible irritation.
Eyes:	Irritation will occur.
Ingestion:	Oral ingestion may cause nausea but should be non-toxic.
Medical Conditions Generally Aggravated by Exposure:	None known.
NTP:	No
IARC Monographs:	No

<u>NOT</u> listed as a carcinogen or potential carcinogen.

ergency/First Aid cedures

Inhalation:	If irritation occurs, move to fresh air.
Eyes:	Immediately flush with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Call a physician immediately.

TECHNICAL BULLETIN

MATERIAL SAFETY DATA SHEET

ULTRA-PURE SL-75 Quick Identifier: 60% Sodium Lactate

Skin:	Immediately flush with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing before reuse.
Ingestion:	Oral ingestion may cause nausea but should be non-toxic. Give victim a cupful of water.

4. PHYSICAL AND CHEMICAL CHARACTERISTICS

Form:	Liquid
Color:	Colorless to slightly amber
pH:	6.0 – 8.5 @ 20°C
Specific Gravity (H_20=1):	1.31 @ 20°C
Vapor Pressure at 20°C:	N/A
Vapor Density (Air=1):	N/A
Evaporation Rate (Butyl Acetate=1):	< 1
Boiling Point:	114°C
Melting Point:	N/A
Solubility in Water:	Complete

5. FIRE AND EXPLOSION DATA

Flash Point (open cup):	N/A
Flammable Limits in Air:	Lower Limit: N/A Upper Limit: N/A
Extinguisher Media:	Water, carbon dioxide (CO2), foam, powder extinguisher
Special Fire-Fighting Procedures:	None. Current standard for chemical fires.
Unusual Fire and Explosion Hazards:	Water may be used to keep fire-exposed containers cool until the fire is out.

6. PHYSICAL HAZARDS (REACTIVITY DATA)

Stability:	Stable under normal conditions.
Incompatibility with other Materials:	None known.
Hazardous Polymerization:	Will not occur.
Hazardous Decomposition or By-Products:	None known.
Conditions to Avoid:	None known.

PURAC

UNCONTROLLED DOCUMENT

Product data

Rev.No.3/3103

PURASAL®P HiPure 60

Description

PURASAL P HiPure is the potassium salt of natural L(+) lactic acid, which is produced by fermentation from sugar. It has no taste impact on the end product, antimicrobial properties and is neutral by pH. PURASAL P HiPure is the ultra pure food grade L-potassium lactate with excellent organoleptic properties.

Specification

Product	L-potassium lactate
Form	liquid
Color fresh	max. 50 apha
Assay	58-62% w/w
Assay potassium	17.7-18.9% w/w
Stereochemical purity (L-isomer)	min. 95%
pH (16.7g product + 83.3g water)	5.5-7.5
pH direct	6.5-8.5
Refractive index at 25°C	1.415-1.422
Density at 20°C	1.32-1.35 g/ml
Sodium	max. 200 ppm
Calcium	max. 20 ppm
Chloride	max. 50 ppm
Sulphate	max. 20 ppm
Iron	max. 10 ppm
Heavy metals total	max. 10 ppm

Physical-chemical properties

Molecular formula	$CH_3CHOHCOOK$
Molecular weight	128 (anhydrous)
Chemical name	Potassium-L-2-hydroxy-propionate

Registration

CAS number	85895-78-9 (general 996-31-6)
EEC additive number	E 326
USA	GRAS
Complies with	FCC and EUSFA

Packaging

PURASAL P HiPure 60 is supplied in 210 L (55 gallon) polyethylene drums (275 kg, 606 lbs), 1000 L (264 gallon) semi-bulk containers (1315 kg, 2899 lbs) and bulk containers.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

UNCONTROLLED DOCUMENT

PURAC

SAFETY DATA SHEET

Potassium Lactate, PURASAL® P

Revision Date: 10/04/03
Ref. SD0150/2003-03

1. IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND THE COMPANY / UNDERTAKING

Product name	Potassium Lactate, PURASAL® P	
# Product code	3101-3107	
Supplier	PURAC America, Inc. 111 Barclay Blvd. Lincolnshire, IL 60069 USA	
Telephone	(847) 634 6330	
Fax	(847) 634 1992	
Emergency Telephone	(800) 424 9300	
Supplier	PURAC biochem Arkelsedijk 46 NL-4206 AC Gorinchem The Netherlands	PURAC bioquimica Gran Via 19-25 E 08160 Montmelo Barcelona Spain
Telephone	++31 183 695695	++34 93 568 6300
Fax	++31 183 695604	++34 93 568 3955
Emergency Telephone	++31 183 695695	++34 93 568 6300 (Ext. 222)

2. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical nature of the substance	Potassium-2-hydroxy propionate aqueous solution.
Synonyms	Potassium Lactate, Potassium-2-hydroxy propionate
CAS-No. 996-31-6	**EC-No** 288-752-8

3. HAZARDS IDENTIFICATION

Most important hazards	May cause eye irritation with susceptible persons.

4. FIRST AID MEASURES

General advice	Show this safety data sheet to the doctor in attendance.
Inhalation	Move to fresh air.
Skin contact	Wash off with water.
Eye contact	Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion	Drink water.
Major effects of exposure	May cause eye irritation with susceptible persons

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Water, carbon dioxide (CO2), foam.
Extinguishing media which must not be used f or safety reasons	None.
Specific hazards	Burning produces irritant fumes.
Special protective equipment for firefighters	None.
Specific methods	Standard procedure for chemical fires.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information;

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Potassium Lactate, PURASAL® P

Revision Date: 10/04/03
Ref. SD0150/2003-03

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Avoid contact with eyes.
Environmental precautions	No special environmental precautions required.
Methods for cleaning up	Flush with water.

7. HANDLING AND STORAGE

Handling

Technical measures/ Precautions	No special technical protective measures required.
Safe handling advice	Handle in accordance with good industrial hygiene and safety practice.

Storage

Technical measures/ Storage conditions	Keep tightly closed.
Packaging material	All steel and plastic packages.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure	Insure adequate ventilation, especially in confined areas.
Control parameters	None.
Personal protection equipment	No special protective equipment required.
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	aqueous solution
Color	light yellow
Odor	slight / none
pH	6.5 - 8.5
Molecular Weight	129
Boiling point/range	239°F (115°C) (60% solution), 257°F (125°C) (80% solution)
Decomposition temperature	>392°F(200°C)
Autoignition temperature	not applicable
Flash point	not applicable
Explosion limits	not applicable
Density	1320 - 1350kg/m^3 (60 % solution)
Solubility	Water solubility: completely soluble
Viscosity	24 - 26 mPa.s @ 68°F(20°C) (60% solution)

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Potassium Lactate, PURASAL® P

Revision Date: 10/04/03
Ref. SD0150/2003-03

10. STABILITY AND REACTIVITY

Stability	Stable at normal conditions.
Conditions to avoid	Temperatures above 392°F(200°C).
Materials to avoid	None.
Hazardous decomposition products	Carbon oxides.

11. TOXICOLOGICAL INFORMATION

Acute toxicity	Health injuries are not known or expected under normal use.
Local effects	May cause eye irritation with susceptible persons.
Specific effects	Based on tests with L-lactic acid and its salts, there is no evidence to suggest carcinogenic nor mutagenic properties from lactic acid itself nor from the lactate portion of its metal salts.

12. ECOLOGICAL INFORMATION

Mobility	Completely soluble in water.
Persistence / degradability	Product is a salt of lactic acid which is readily biodegradable.
Bioaccumulation	Unlikely.
Ecotoxicity	Ecological injuries are not known or expected under normal use. (No effect on Daphnia @ 10g/l.)

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products	Can be disposed as waste water, when in compliance with local regulations. Can be landfilled or incinerated, when in compliance with local regulations.
Contaminated packaging	Clean container with water. Empty containers should be taken for local recycling, recovery or waste disposal.

14. TRANSPORT INFORMATION

Not classified as dangerous in the meaning of transport regulations.

15. REGULATORY INFORMATION

US Regulations	TSCA Inventory Status: Y SARA III: N California Proposition 65: N Carcinogenic status: OSHA: N, NTP: N, IARC: N FDA: GRAS
EU Status	According to National equivalent of EC-Dir. 67/548, as amended, the product does not need to be labeled.
EU Food additive E326	

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained therein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PURAC

SAFETY DATA SHEET

Potassium Lactate, PURASAL® P

Revision Date: 10/04/03
Ref. SD0150/2003-03

16. OTHER INFORMATION

NFPA Ratings (Scale 0-4): 0(health)-0(flammability)-0(reactivity)
HMIS Rating: 0(health)-0(flammability)-0(reactivity)-A (protective equipment)

Further information on the safety assessment of Potassium Lactate and lactic acid can be obtained in a CFTA Report of June 6th 1997.

Additional data on the calculated ecotoxicity of lactic acid and its salts and esters can be obtained in a report entitled 'The ecotoxicity and biodegradability of lactic acid, alkyl lactate esters and lactic acid salts' by Bowmer et al.
(Reference: Chemosphere 37: 1317-1333 (1998))

# Indicates updated section.

Copyright © PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded, or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

For further information:

http://www.purac.com/

PRODUCT SPECIFICATIONS

Product: Ultra-Pure PL-85 (60%)

Contents: Potassium Lactate ($CH_3CHOHCOOK$)

USA:	GRAS (21CFR – 184.1639)
EEC Additive Number:	E:326
CAS Number:	996-31-6/7732-18-5

Description:

Ultra-Pure PL-85 is a mild-flavored potassium salt of lactic acid that offers unique antimicrobial properties. Natural lactic acid is produced from the fermentation of sugar. The exclusive Ultra-Pure process greatly reduces the objectionable flavors or aftertaste common to most commercial lactates. The result is a clean-flavored and pH consistent food grade L-potassium lactate.

Specifications:

Form	Aqueous solution
Flavor	Slight tanginess
Appearance	Clear to slightly amber
Color	50 apha max
Density @ 20° C	1.31 – 1.34 g/ml
Assay, potassium lactate	58% - 62%
pH	6.0 – 8.5
Potassium	18.6% - 20.6%
Sodium	0.25% max
Chloride	50 ppm max
Sulfate	20 ppm max
Heavy Metals, as Pb	5 ppm max

Government Regulations & Labeling:

Meets FCC (when sodium level is max 0.10%), is Kosher Certified and is affirmed GRAS by the FDA. USDA/FSIS permits potassium lactate to be used up to 4.8% in both standard and non-specific meat and poultry products. It should be listed on the product ingredient statement as "potassium lactate".

Packaging:

55-lb (25 kg) plastic pails, 600-lb (272.1 kg) plastic drums and 2875-lb (1303.9 kg) bulk totes.

Storage:

Hold in dry room at room temperature.

This information is presented for your consideration in the belief that it is accurate and reliable; however, no warranty either expressed or implied is made and no freedom from liability from patents, trademarks, or other limitations should be inferred. The data listed are average values only, and are not to be considered as guarantees expressed or implied, nor as a condition of sale. Typical analysis data which should not be constructed as being specifications fall within the range of standard manufacturing practices. Product as received will vary within this range. TRUMARK, INC. has no control over the transportation, storage, handling or use of the product made by purchasers or others we cannot be responsible for damages resulting from the use of such product. TRUMARK, INC. warrants only that when shipped from its facility the product will meet published specifications. No warranty of merchantability or fitness for a particular purpose is given or implied.

04.29.03

MARK INC

830 EAST ELIZABETH AVENUE ■ LINDEN, N.J. 07036 USA ■ (908) 486-5900 ■ (800) 752-7877 ■ FAX (908) 486-5905 ■ EMAIL [illegible]

TECHNICAL BULLETIN

MATERIAL SAFETY DATA SHEET

ULTRA-PURE PL-85

Quick Identifier: 60% Potassium Lactate
Revision Date: 04 June 2003

GENERAL INFORMATION

Manufacturer's Name:	Trumark Inc.
Address:	830 E. Elizabeth Avenue Linden, NJ 07036 USA
Telephone Number:	908-486-5900 or 800-752-7877 (in the USA)
Fax Number:	908-486-5905
Emergency Number:	Chemtrec (800-424-9300 in the USA) or 703-527-3887

HAZARDOUS INGREDIENTS/ IDENTITY

Emergency Overview:	No health concerns are known or expected under normal use.
CAS Number:	Potassium Lactate 60% (996-31-6) Water 40% (7732-18-5)
OSHA/PEL:	N/A
ACGIH/TLV:	N/A

HEALTH HAZARDS

Inhalation:	None known.
Skin:	Possible irritation.
Eyes:	Irritation will occur.
Ingestion:	Oral ingestion may cause nausea but should be non-toxic.
Medical Conditions Generally Aggravated by Exposure:	None known.
NTP:	No
IARC Monographs:	No

NOT listed as a carcinogen or potential carcinogen.

rgency/First Aid edures

Inhalation:	If irritation occurs, move to fresh air.
Eyes:	Immediately flush with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Call a physician immediately.

TECHNICAL BULLETIN

MATERIAL SAFETY DATA SHEET

ULTRA-PURE PL-85 | Quick Identifier: 60% Potassium Lactate

	Skin:	Immediately flush with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing before reuse.
	Ingestion:	Oral ingestion may cause nausea but should be non-toxic. Give victim a cupful of water.
4. PHYSICAL AND CHEMICAL CHARACTERISTICS	Form:	Liquid
	Color:	Colorless to slightly amber
	pH:	6.0 – 8.5 @ 20°C
	Specific Gravity (H_2O=1):	1.31 @ 20°C
	Vapor Pressure at 20°C:	N/A
	Vapor Density (Air=1):	N/A
	Evaporation Rate (Butyl Acetate=1):	< 1
	Boiling Point:	110°C
	Melting Point:	N/A
	Solubility in Water:	Complete
5. FIRE AND EXPLOSION DATA	Flash Point (open cup):	N/A
	Flammable Limits in Air:	Lower Limit: N/A Upper Limit: N/A
	Extinguisher Media:	Water, carbon dioxide (CO2), foam, powder extinguisher
	Special Fire-Fighting Procedures:	None. Current standard for chemical fires.
	Unusual Fire and Explosion Hazards:	Water may be used to keep fire-exposed containers cool until the fire is out.
6. PHYSICAL HAZARDS (REACTIVITY DATA)	Stability:	Stable under normal conditions.
	Incompatibility with other Materials:	None known.
	Hazardous Polymerization:	Will not occur.
	Hazardous Decomposition or By-Products:	None known.
	Conditions to Avoid:	None known.

TECHNICAL BULLETIN

MATERIAL SAFETY DATA SHEET

ULTRA-PURE PL-85 Quick Identifier: 60% Potassium Lactate

SPECIAL PRECAUTION AND SPILL/LEAK PROCEDURES	Handling and Storage:	Personal Precautionary Measures – Respiratory protection not required. Safety glasses recommended. Handle in accordance with appropriate safety and hygiene practices. Storage – Keep container closed. Store at room temperature in a dry area.
	Accidental Release Measures:	Use personal protective equipment. No special environmental precautions identified. Absorb excess and wash spill area with water.
	Disposal Considerations:	Discharge, treatment or disposal may be subject to national, state/provincial or local regulations.
	Ecological Information:	Contains no known substances hazardous to the environment. Degradable in waste water treatment facilities.
SPECIAL PROTECTION INFORMATION/ CONTROL MEASURES	Exposure Limits:	None known.
	Ventilation:	Local exhaust.
	Respiratory Protection:	None required.
	Eye Protection:	Wear safety glasses with side shields (or goggles).
	Skin Protection:	Chemical-resistant gloves are recommended if irritation occurs.
TRANSPORTATION INFORMATION	Not considered dangerous or hazardous for air, sea and road freight.	

nformation contained herein is based on current knowledge and experience; no responsibility is accepted that the information is sufficient or correct in all s. Users should consider these data only as a supplement to other information gathered by them and must make independent determinations of y and completeness of information from all sources to assure proper use and disposal of these materials and the safety and health of employees and s and the protection of the environment.

Monograph Specification

Sodium Lactate
pgs. 365 - 367

Carbonate (as Na_2CO_3) Not more than 3.0%, calculated on the basis of NaOH determined in the *Assay*.
Heavy Metals (as Pb) Not more than 0.002%, calculated on the basis of NaOH determined in the *Assay*.
Lead Not more than 10 mg/kg, calculated on the basis of NaOH determined in the *Assay*.
Mercury Not more than 1 mg/kg, calculated on the basis of NaOH determined in the *Assay*.

TESTS

Assay Based on the stated or labeled percentage of NaOH, weigh accurately a volume of the solution equivalent to about 1.5 g of sodium hydroxide, and dilute it to 40 mL with recently boiled and cooled water. Continue as directed under *Assay* in the monograph for *Sodium Hydroxide*, beginning with "...cool to 15°...."
Arsenic Dilute the equivalent of 1 g of NaOH, calculated on the basis of the *Assay*, to 10 mL with water, cautiously neutralize to litmus paper with sulfuric acid, and cool. This solution meets the requirements of the *Arsenic Test*, Appendix IIIB.
Carbonate Each mL of 1 *N* sulfuric acid required between the phenolphthalein and methyl orange endpoints in the *Assay* is equivalent to 106.0 mg of Na_2CO_3.
Heavy Metals Dilute the equivalent of 1 g of NaOH, calculated on the basis of the *Assay*, with a mixture of 5 mL of water and 11 mL of 2.7 *N* hydrochloric acid, and heat to boiling. Cool, dilute to 25 mL with water, and filter. This solution meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 µg of lead ion (Pb) in the control (*Solution A*).
Lead Dilute the equivalent of 1 g of NaOH, calculated on the basis of the *Assay*, with a mixture of 5 mL of water and 11 mL of 2.7 *N* hydrochloric acid. This solution meets the requirements of the *Lead Limit Test*, Appendix IIIB, using 10 µg of lead ion (Pb) in the control.
Mercury Determine as directed under *Mercury Limit Test*, Appendix IIIB, using the following as the *Sample Preparation*: Transfer an accurately weighed amount of the sample, equivalent to 2.0 g of NaOH, into a 50-mL beaker, add 10 mL of water and 2 drops of phenolphthalein TS, and slowly neutralize, with constant stirring, with dilute hydrochloric acid solution (1 in 2). Add 1 mL of dilute sulfuric acid solution (1 in 5) and 1 mL of potassium permanganate solution (1 in 25), cover the beaker with a watch glass, boil for a few s, and cool.

Packaging and Storage Store in tight containers.

Sodium Hypophosphite

$NaH_2PO_2.H_2O$

Formula wt 105.99

CAS: [7681-53-0]

DESCRIPTION

Sodium Hypophosphite occurs as a white crystalline powder, as white granules, or as colorless, pearly crystalline plates. It is very deliquescent. One mL of water dissolves about 1 g at 25° and about 6 g at 100°. It is slightly soluble in alcohol.

Caution: Care should be observed in mixing Sodium Hypophosphite with nitrates, chlorates, or other oxidizing agents, as an explosion may occur if triturated or heated.

Functional Use in Foods Preservative; antioxidant.

REQUIREMENTS

Identification A 1 in 20 solution gives positive tests for *Sodium* and for *Hypophosphites*, Appendix IIIA.
Assay Not less than 97.0% and not more than 103.0% of $NaH_2PO_2.H_2O$.
Fluoride Not more than 10 mg/kg.
Heavy Metals (as Pb) Not more than 10 mg/kg.
Insoluble Substances Not more than 0.1%.

TESTS

Assay Dissolve about 100 mg of the sample, accurately weighed, in 20 mL of water, add 40.0 mL of 0.1 *N* ceric sulfate, mix well, and add 2 mL of silver sulfate solution (5 g of Ag_2SO_4 dissolved in 95 mL of concentrated sulfuric acid). Cover, heat nearly to boiling, and continue heating for 30 min. Cool to room temperature, and titrate with 0.1 *N* ferrous sulfate to a pale yellow color. Add 2 drops of orthophenanthroline TS, and continue the titration to a salmon-colored endpoint, recording the volume required, in mL, as *S*. Perform a residual blank titration (see *General Provisions*), and record the volume required as *B*. Each mL of the volume $B - S$ is equivalent to 2.650 mg of $NaH_2PO_2.H_2O$.
Fluoride Proceed as directed in the *Fluoride Limit Test*, Appendix IIIB.
Heavy Metals A solution of 2 g in 25 mL of water meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 µg of lead ion (Pb) in the control (*Solution A*).
Insoluble Substances Dissolve 10 g of the sample in 100 mL of hot water, and filter through a tared filtering crucible. Wash the residue with hot water, dry at 105° for 2 h, cool, and weigh.

Packaging and Storage Store in tight containers.

Sodium Lactate Solution

2-Hydroxy-Propanoic Acid, Monosodium Salt

$C_3H_5NaO_3$ Formula wt 112.06

DESCRIPTION

Sodium Lactate Solution is a clear, colorless or practically colorless, slightly viscous liquid, odorless or having a slight, not unpleasant odor. It is miscible with water, and it is normally available in a concentration range of 60% to about 80% of $C_3H_5NaO_3$, by weight.

Functional Use in Foods Emulsifier; flavor enhancer; flavoring agent or adjuvant; humectant; pH control agent.

REQUIREMENTS

Labeling Indicate its content, by weight, of sodium lactate, $C_3H_5NaO_3$.

Identification It gives positive tests for *Sodium* and for *Lactate*, Appendix IIIA.

Assay Not less than 50.0%, by weight, and not less than 98.0% and not more than 102.0%, by weight, of the labeled amount of $C_3H_5NaO_3$.

Chloride Not more than 0.05%.

Citrate, Oxalate, Phosphate, or Tartrate Passes test.

Cyanide Not more than 0.5 mg/kg.

Heavy Metals (as Pb) Not more than 10 mg/kg.

Lead Not more than 5 mg/kg.

Methanol and Methyl Esters Not more than 0.025%.

pH Between 5.0 and 9.0.

Sugars Passes test.

Sulfate Not more than 0.005%.

TESTS

Assay Weigh accurately into a suitable flask a volume of Sodium Lactate Solution, equivalent to about 300 mg of sodium lactate. Add 60 mL of a 1 in 5 mixture of acetic anhydride in glacial acetic acid, mix, and allow to stand for 20 min. Titrate with 0.1 *N* perchloric acid in glacial acetic acid, determining the endpoint potentiometrically. Perform a blank determination, and make any necessary correction. Each mL of 0.1 *N* perchloric acid is equivalent to 11.21 mg of $C_3H_5NaO_3$.

Chloride, Appendix IIIB Any turbidity produced by a quantity of the solution containing the equivalent of 40 mg of sodium lactate does not exceed that shown in a control containing 20 µg of chloride ion (Cl).

Citrate, Oxalate, Phosphate, or Tartrate Dilute 5 mL with recently boiled and cooled water to 50 mL. To 4 mL of this solution add 6 *N* ammonium hydroxide or 3 *N* hydrochloric acid, if necessary, to bring the pH to between 7.3 and 7.7. Add 1 mL of calcium chloride TS, and heat in a boiling water bath for 5 min: The solution remains clear.

Cyanide (**Caution**: Because of the extremely poisonous nature of potassium cyanide, conduct this test in a fume hood, and exercise great care to prevent skin contact and inhaling particles or vapors of solutions of the material. Under no conditions pipet solutions by mouth.)

p-Phenylenediamine–Pyridine Mixed Reagent Dissolve 200 mg of *p*-phenylenediamine hydrochloride in 100 mL of water, warming to aid dissolution. Cool, allow the solids to settle, and use the supernatant liquid to make the mixed reagent. Dissolve 128 mL of pyridine in 365 mL of water, add 10 mL of hydrochloric acid, and mix. To prepare the mixed reagent, mix 30 mL of the *p*-phenylenediamine solution with all of the pyridine solution and allow to stand for 24 h before using. The mixed reagent is stable for about 3 weeks when stored in an amber bottle.

Sample Solution Transfer an accurately weighed quantity of the Solution, equivalent to 20.0 g of sodium lactate, into a 100-mL volumetric flask, dilute to volume with water, and mix.

Cyanide Standard Solution Dissolve 250 mg of po[illegible] cyanide, accurately weighed, in 10 mL of 0.1 *N* sodium hy[illegible] ide in a 100 mL volumetric flask, dilute to volume with [illegible] sodium hydroxide, and mix. Transfer a 10-mL aliquo[illegible] 1000-mL volumetric flask, dilute to volume with 0.1 *N* [illegible] hydroxide, and mix. Each mL of this solution contains [illegible] of cyanide.

Procedure Pipet a 10-mL aliquot of the *Sample So*[illegible] into a 50-mL beaker. Into a second 50-mL beaker, pipet [illegible] mL of the *Cyanide Standard Solution*, and add 10 mL of [illegible] Place the beakers in an ice bath, and adjust the pH to betw[illegible] 9 and 10 with 20% sodium hydroxide, stirring slowly and add[illegible] the reagent slowly to avoid overheating. Allow the solution [illegible] stand for 3 min, and then slowly add 10% phosphoric acid [illegible] a pH between 5 and 6, measured with a pH meter.

Transfer the solutions into 100-mL separators containing [illegible] mL of cold water, and rinse the beakers and pH meter electrode [illegible] with a few mL of cold water, collecting the washings in the respective separator. Add 2 mL of bromine TS, stopper, and mix. Add 2 mL of 2% sodium arsenite solution, stopper, and mix. To the clear solutions add 10 mL of *n*-butanol, stopper, and mix. Finally, add 5 mL of *p-Phenylenediamine–Pyridine Mixed Reagent*, mix, and allow to stand for 15 min. Remove and discard the aqueous phases, and filter the alcohol phases into 1-cm cells. The absorbance of the solution from the *Sample Solution*, determined at 480 nm with a suitable spectrophotometer, is no greater than that from the *Cyanide Standard Solution*.

Heavy Metals Dilute a quantity of the Solution, equivalent to 2.0 g of sodium lactate, to 25 mL with water. This solution meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 µg of lead ion (Pb) in the control (*Solution A*).

Lead Dilute a quantity of the Solution, equivalent to 2.0 g of sodium lactate, to 25 mL with water. This solution meets the requirements of the *Lead Limit Test*, Appendix IIIB, using 10 µg of lead ion (Pb) in the control.

Methanol and Methyl Esters

Potassium Permanganate and Phosphoric Acid Solution Dissolve 3 g of potassium permanganate in a mixture of 15 mL of phosphoric acid and 70 mL of water. Dilute with water to 100 mL.

Oxalic Acid and Sulfuric Acid Solution Cautiously add 50 mL of sulfuric acid to 50 mL of water, mix, cool, add 5 g of oxalic acid, and mix to dissolve.

Standard Preparation Prepare a solution containing 10.0 mg of methanol in 100 mL of dilute alcohol (1 in 10).

Test Preparation Place 40.0 g of the Solution in a glass-stoppered, round-bottom flask, add 10 mL of water, and add cautiously 30 mL of 5 *N* potassium hydroxide. Connect a condenser to the flask, and steam-distill, collecting the distillate in a suitable 100-mL graduated vessel containing 10 mL of alcohol. Continue the distillation until the volume in the receiver reaches approximately 95 mL, and dilute the distillate with water to 100.0 mL.

Procedure Transfer 10.0 mL each of the *Standard Preparation* and the *Test Preparation* to 25-mL volumetric flasks. To each add 5.0 mL of *Potassium Permanganate and Phosphoric Acid Solution*, and mix. After 15 min, to each add 2.0 mL of *Oxalic Acid and Sulfuric Acid Solution*, stir with a glass rod until the solution is colorless, add 5.0 mL of fuchsin–sulfurous

acid TS (prepared as directed under *Solutions and Indicators*), dilute with water to volume, and mix. After 2 h, concomitantly determine the absorbances of both solutions in 1-cm cells at the wavelength of maximum absorbance at about 575 nm, with a suitable spectrophotometer, using water as the blank: The absorbance of the solution from the *Test Preparation* is not greater than that from the *Standard Preparation*.

pH Determine the pH of the Solution by the *Potentiometric Method*, Appendix IIB.

Sugars To 10 mL of hot alkaline cupric tartrate TS add 5 drops of Sodium Lactate Solution: No red precipitate is formed.

Sulfate, Appendix IIIB Any turbidity produced by a quantity of the Solution containing the equivalent of 4.0 g of sodium lactate does not exceed that shown in a control containing 200 μg of sulfate ion (SO_4).

Packaging and Storage Store in tight containers.

Sodium Lauryl Sulfate

INS: 487 CAS: [151-21-3]

DESCRIPTION

Sodium Lauryl Sulfate is a mixture of sodium alkylsulfates consisting chiefly of Sodium Lauryl Sulfate [$CH_3(CH_2)_{10}CH_2O$-SO_3Na]. It occurs as small, white or light yellow crystals having a slight, characteristic odor. One g dissolves in 10 mL of water, forming an opalescent solution.

Functional Use in Foods Surface-active agent.

REQUIREMENTS

Identification A 1 in 10 solution gives positive tests for *Sodium*, Appendix IIIA and, after acidification with hydrochloric acid and boiling gently for 20 min, responds to the tests for *Sulfate*, Appendix IIIA.

Assay Not less than 59.0% of total alcohols.

Alkalinity (as NaOH) Passes test (about 0.25%).

Combined Sodium Chloride and Sodium Sulfate Not more than 8.0%.

Heavy Metals (as Pb) Not more than 0.002%.

Lead Not more than 5 mg/kg.

Unsulfated Alcohols Not more than 4.0%.

TESTS

Assay Transfer about 5 g, accurately weighed, to an 800-mL Kjeldahl flask, and add 150 mL of water, 50 mL of hydrochloric acid, and a few boiling chips. Attach a reflux condenser to the flask, heat carefully to avoid excessive frothing, and then boil for about 4 h. Cool the flask, rinse the condenser with ether, collecting the ether in the flask, and transfer the contents to a 500-mL separator, rinsing the flask twice with ether and adding the washings to the separator. Extract the solution with two 75-mL portions of ether, evaporate the combined ether extracts in a tared beaker on a steam bath, dry the residue at 105° for 30 min, cool, and weigh. The residue represents the total alcohols.

Alkalinity Dissolve 1 g in 100 mL of water, add phenol red TS, and titrate with 0.1 *N* hydrochloric acid. Not more than 0.5 mL is required for neutralization.

Combined Sodium Chloride and Sodium Sulfate

Sodium Chloride Dissolve about 5 g, accurately weighed, in about 50 mL of water. Neutralize the solution with dilute nitric acid (1 in 20), using litmus paper as the indicator, add 2 mL of potassium chromate TS, and titrate with 0.1 *N* silver nitrate. Each mL of 0.1 *N* silver nitrate is equivalent to 5.844 mg of sodium chloride.

Sodium Sulfate Transfer about 1 g, accurately weighed, to a 400-mL beaker, add 10 mL of water, heat the mixture, and stir until completely dissolved. To the hot solution add 100 mL of alcohol, cover, and digest at a temperature just below the boiling point for 2 h. Filter while hot through a sintered-glass filter crucible, and wash the precipitate with 100 mL of hot alcohol. Dissolve the precipitate in the crucible by washing with about 150 mL of water, collecting the washings in a beaker. Acidify with 10 mL of hydrochloric acid, heat to boiling, add 25 mL of barium chloride TS, and allow to stand overnight. Collect the precipitate of barium sulfate on a suitable tared, porous-bottom porcelain filter crucible, wash until free from chloride, dry, and ignite to constant weight at 800° ± 25°. The weight of barium sulfate so obtained, multiplied by 0.6086, represents the weight of Na_2SO_4.

Note: Avoid exposing the crucible to sudden temperature changes.

Heavy Metals A solution of 1 g in 25 mL of water meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 μg of lead ion (Pb) in the control (*Solution A*).

Lead A *Sample Solution* prepared as directed for organic compounds meets the requirements of the *Lead Limit Test*, Appendix IIIB, using 5 μg of lead ion (Pb) in the control.

Unsulfated Alcohols Dissolve about 10 g, accurately weighed, in 100 mL of water, and add 100 mL of alcohol. Transfer the solution to a separator, and extract with three 50-mL portions of solvent hexane. If an emulsion forms, sodium chloride may be added to promote separation of the two layers. Wash the combined solvent hexane extracts with three 50-mL portions of water, and dry with anhydrous sodium sulfate. Filter the solvent hexane extract into a tared beaker, evaporate on a steam bath until the odor of solvent hexane no longer is perceptible, dry the residue at 105° for 30 min, cool, and weigh. The residue represents the unsulfated alcohols.

Packaging and Storage Store in well-closed containers.

Potassium Lactate
Pgs. 321 - 322

Potassium Lactate Solution

2-Hydroxy-Propanoic Acid, Monopotassium Salt

$C_3H_5KO_3$ Formula wt 128.17

DESCRIPTION

Clear, colorless, or practically colorless, viscous liquid, odorless or having a slight, not unpleasant, odor. It is miscible with water. It is available as solutions with concentrations ranging from about 50% to 70%.

Functional Use in Foods Emulsifier; flavor enhancer; flavoring agent or adjuvant; humectant; pH control agent.

REQUIREMENTS

Labeling Indicate its content, by weight, of Potassium Lactate, $C_3H_5KO_3$.
Identification It gives positive tests for *Potassium* and for *Lactate*, Appendix IIIA.
Assay Not less than 50.0%, by weight, and not less than 95.0% and not more than 105.0%, by weight, of the labeled amount of Potassium Lactate, $C_3H_5KO_3$.
Chloride Not more than 0.05%.
Citrate, Oxalate, Phosphate, or Tartrate Passes test.
Cyanide Not more than 0.5 mg/kg.
Heavy Metals (as Pb) Not more than 10 mg/kg.
Lead Not more than 5 mg/kg.
Methanol and Methyl Esters Not more than 0.025%.
pH Between 5.0 and 9.0.
Sodium Not more than 0.1%.
Sugars Passes test.
Sulfate Not more than 0.005%.

TESTS

Assay Weigh accurately into a suitable flask a volume of Potassium Lactate Solution equivalent to about 500 mg of potassium lactate, add 60 mL of a 1 in 5 mixture of acetic anhydride in glacial acetic acid, mix, and allow to stand for 20 min. Titrate with 0.1 *N* perchloric acid in glacial acetic acid, determining the endpoint potentiometrically. Perform a blank determination, and make any necessary correction. Each mL of 0.1 *N* perchloric acid is equivalent to 12.82 mg of $C_3H_5KO_3$.
Chloride, Appendix IIIB Any turbidity produced by a quantity of the Solution containing the equivalent of 40 mg of potassium lactate does not exceed that shown in a control containing 20 µg of chloride ion (Cl).
Citrate, Oxalate, Phosphate, or Tartrate Dilute 5 mL with recently boiled and cooled water to 50 mL. To 4 mL of this solution, add 6 *N* ammonium hydroxide or 3 *N* hydrochloric acid, if necessary, to bring the pH to between 7.3 and 7.7. Add 1 mL of calcium chloride TS, and heat in a boiling water bath for 5 min. The solution remains clear.
Cyanide (**Caution**: Because of the extremely poisonous nature of potassium cyanide, conduct this test in a fume hood, and exercise great care to prevent skin contact and inhaling particles or vapors of solutions of the material. Under no conditions pipet solutions by mouth.)

p-Phenylenediamine–Pyridine Mixed Reagent Dissolve 200 mg of *p*-phenylenediamine hydrochloride in 100 mL of water, warming to aid dissolution. Cool, allow the solids to settle, and use the supernatant liquid to make the mixed reagent. Dissolve 128 mL of pyridine in 365 mL of water, add 10 mL of hydrochloric acid, and mix. To prepare the mixed reagent, mix 30 mL of the *p*-phenylenediamine solution with all of the pyridine solution, and allow to stand for 24 h before using. The mixed reagent is stable for about 3 weeks when stored in an amber bottle.

Sample Solution Transfer an accurately weighed quantity of the Solution, equivalent to 20.0 g of potassium lactate, into a 100-mL volumetric flask, dilute to volume with water, and mix.

Cyanide Standard Solution Dissolve 250 mg of potassium cyanide, accurately weighed, in 10 mL of 0.1 *N* sodium hydroxide in a 100-mL volumetric flask, dilute to volume with 0.1 *N* sodium hydroxide, and mix. Transfer a 10-mL aliquot into a 1000-mL volumetric flask, dilute to volume with 0.1 *N* sodium hydroxide, and mix. Each mL of this solution contains 10 µg of cyanide.

Procedure Pipet a 10-mL aliquot of the *Sample Solution* into a 50-mL beaker. Into a second 50-mL beaker, pipet 0.10 mL of the *Cyanide Standard Solution*, and add 10 mL of water. Place the beakers in an ice bath, and adjust the pH to between 9 and 10 with 20% sodium hydroxide, stirring slowly and adding the reagent slowly to avoid overheating. Allow the solutions to stand for 3 min, and then slowly add 10% phosphoric acid to a pH between 5 and 6, measured with a pH meter. Transfer the solutions into 100-mL separators containing 25 mL of cold water, and rinse the beakers and pH meter electrodes with a few mL of cold water, collecting the washings in the respective separator. Add 2 mL of bromine TS, stopper, and mix. Add 2 mL of 2% sodium arsenite solution, stopper, and mix. Add 10 mL of *n*-butanol to the clear solutions, stopper, and mix. Finally, add 5 mL of *p-Phenylenediamine–Pyridine Mixed Reagent*, mix, and allow to stand for 15 min. Remove and discard the aqueous phases, and filter the alcohol phases into 1-cm cells. The absorbance of the solution from the *Sample Solution*, determined at 480 nm with a suitable spectrophotometer, is not greater than that from the *Cyanide Standard Solution*.
Heavy Metals Dilute a quantity of the Solution, equivalent to 2.0 g of potassium lactate, to 25 mL with water. This solution meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 µg of lead ion (Pb) in the control (*Solution A*).
Lead Dilute a quantity of the Solution, equivalent to 2.0 g of potassium lactate, to 25 mL with water. This solution meets the requirements of the *Lead Limit Test*, Appendix IIIB, using 10 µg of lead ion (Pb) in the control.
Methanol and Methyl Esters

Potassium Permanganate and Phosphoric Acid Solution Dissolve 3 g of potassium permanganate in a mixture of 15 mL of phosphoric acid and 70 mL of water. Dilute with water to 100 mL.

Oxalic Acid and Sulfuric Acid Solution Cautiously add 50 mL of sulfuric acid to 50 mL of water, mix, cool, add 5 g of oxalic acid, and mix to dissolve.

Standard Preparation Prepare a solution containing 10.0 mg of methanol in a 100-mL volumetric flask, dilute to volume with dilute alcohol (1 in 10), and mix.

Test Preparation Place 40.0 g of the Solution in a glass-stoppered, round-bottom flask, add 10 mL of water, and cautiously add 30 mL of 5 *N* potassium hydroxide. Connect a condenser to the flask, and steam-distill, collecting the distillate in a suitable 100-mL graduated vessel containing 10 mL of alcohol. Continue the distillation until the volume in the receiver reaches approximately 95 mL, and dilute the distillate with water to 100.0 mL.

Procedure Transfer 10.0 mL each of the *Standard Preparation* and the *Test Preparation* to separate 25-mL volumetric flasks. To each, add 5.0 mL of *Potassium Permanganate and Phosphoric Acid Solution*, and mix. After 15 min, add 2.0 mL of *Oxalic Acid and Sulfuric Acid Solution* to each, stir with a glass rod until the solution is colorless, add 5.0 mL of fuchsin–sulfurous acid TS (prepared as directed in *Solutions and Indicators*), dilute with water to volume, and mix. After 2 h, concomitantly determine the absorbances of both solutions in 1-cm cells at the wavelength of maximum absorbance at about 575 nm, with a suitable spectrophotometer and using water as the blank: The absorbance of the solution from the *Test Preparation* is not greater than that from the *Standard Preparation*.

pH Determine the pH of the Solution by the *Potentiometric Method*, Appendix IIB.

Sodium

Potassium Chloride Solution Dissolve 100 g of potassium chloride in water and dilute to 1000 mL.

Standard Solutions Transfer 127.1 mg of sodium chloride, previously dried at 105° for 2 h and accurately weighed, to a 500-mL volumetric flask, dilute with water to volume, and mix. Transfer 10.0 mL of this solution to a 100-mL volumetric flask, dilute with water to volume, and mix to obtain a *Stock Solution* containing 10 µg of sodium per mL. Into separate 100-mL volumetric flasks, pipet 1-, 2-, 5-, and 10-mL aliquots of the *Stock Solution*; add 1.0 mL of *Potassium Chloride Solution* followed by 1.0 mL of nitric acid; dilute with water to volume; and mix to obtain *Standard Solutions* containing 0.1, 0.2, 0.5, and 1.0 µg of sodium per mL, respectively.

Test Solution Transfer an accurately weighed quantity of the Solution equivalent to about 4 g of potassium lactate to a 50-mL volumetric flask, dilute to volume with water, and mix. Pipet 1 mL of this solution into a 100-mL volumetric flask, add 1.0 mL of *Potassium Chloride Solution* followed by 1.0 mL of nitric acid, dilute with water to volume, and mix.

Blank Solution Transfer 1.0 mL of *Potassium Chloride Solution* to a 100-mL volumetric flask, add 1.0 mL of nitric acid, dilute with water to volume, and mix.

Procedure Concomitantly determine the absorbances of the *Standard Solutions* and the *Test Solution* at the sodium emission line of 589 nm with a suitable atomic absorption spectrophotometer equipped with a sodium hollow-cathode lamp and an oxidizing air–acetylene flame, using the *Blank Solution* to zero the instrument. Plot the absorbances of the *Standard Solutions* versus concentration, in µg/mL, of sodium, and draw the straight line that best fits the plotted points. From the graph so obtained, determine the concentration *C*, in µg/mL, of sodium in the *Test Solution*. Calculate the percentage of sodium in the portion of potassium lactate taken by the formula

$$CD/10{,}000W,$$

in which *W* is the quantity, in g, of potassium lactate taken to prepare the *Test Solution*, and *D* is the dilution factor for the *Test Solution*.

Sugars To 10 mL of hot alkaline cupric tartrate TS add 5 drops of Potassium Lactate Solution: No red precipitate is formed.

Sulfate, Appendix IIIB Any turbidity produced by a quantity of the Solution containing the equivalent of 4.0 g of potassium lactate does not exceed that shown in a control containing 200 µg of sulfate ion (SO_4).

Packaging and Storage Store in tight containers.

Potassium Metabisulfite

Potassium Pyrosulfite

$K_2S_2O_5$

INS: 224 Formula wt 222.33

CAS: [16731-55-8]

DESCRIPTION

White or colorless, free-flowing crystals, crystalline powder, or granules, usually having an odor of sulfur dioxide. It gradually oxidizes in air to the sulfate. It is soluble in water, and is insoluble in alcohol. Its solutions are acid to litmus.

Functional Use in Foods Preservative; antioxidant; bleaching agent.

REQUIREMENTS

Identification A 1 in 10 solution gives positive tests for *Potassium* and for *Sulfite*, Appendix IIIA.

Assay Not less than 90.0% of $K_2S_2O_5$.

Heavy Metals (as Pb) Not more than 10 mg/kg.

Iron Not more than 10 mg/kg.

Selenium Not more than 0.003%.

TESTS

Assay Weigh accurately about 250 mg, add it to exactly 50 mL of 0.1 *N* iodine contained in a glass-stoppered flask, and stopper the flask. Allow to stand for 5 min, add 1 mL of hydrochloric acid, and titrate the excess iodine with 0.1 *N* sodium thiosulfate, using starch TS as the indicator. Each mL of 0.1 *N* iodine is equivalent to 5.558 mg of $K_2S_2O_5$.

Heavy Metals Dissolve 2 g in 20 mL of water, add 5 mL of hydrochloric acid, evaporate to about 1 mL on a steam bath, and dissolve the residue in 25 mL of water. This solution meets the requirements of the *Heavy Metals Test*, Appendix IIIB, using 20 µg of lead ion (Pb) in the control (*Solution A*).

Excluded Methods Letter

TRUMARK INC 830 EAST ELIZABETH AVENUE ■ LINDEN, N.J. 07036 USA

This letter is to confirm that our potassium lactate and sodium lactate are produced and handled without the use of excluded methods as per the USDA NOP standards [reference 7 CFR Part 205.301 (c)].

TRUMARK INC.

EMAIL trumark@trumarkinc.com (800) 752-7877 (908) 486-5900 FAX (908) 486-5905

Reviews and Studies

Journal of Food Protection, Vol. 54, No. 4, Pages 283-287 (April 1991)
Copyright© International Association of Milk, Food and Environmental Sanitarians

23

19 #390

Growth Suppression of *Listeria monocytogenes* by Lactates in Broth, Chicken, and Beef

LEORA A. SHELEF* and QIAN YANG

Department of Nutrition and Food Science, Wayne State University, Detroit, Michigan 48202

(Received for publication August 20, 1990)

ABSTRACT

Sodium or potassium lactate is available commercially as a neutral aqueous solution (60%), approved for use as a flavoring agent in meat and poultry products. While recommended also for extending shelf life, little work on its antimicrobial effects has been published and none in relation to *Listeria monocytogenes*. Studies in tryptic soy broth showed that concentrations higher than 5% delayed growth of three strains of *L. monocytogenes*. Experiments in sterile comminuted chicken and beef at 35, 20, and 5° showed growth suppression by 4% lactate, which increased with decrease in storage temperature. The organism was consistently more sensitive to lactate in beef than in chicken, displaying an extended lag phase of 1-2 weeks at 5°C. Combinations of lactate (4%) with NaCl (3%) or nitrate (140 ppm) did not enhance the effect. Lactate did not alter the beef or chicken pH, and no difference was observed between the effect of the two salts, nferring that the lactate ion is responsible for the delay in listerial h.

Sodium lactate is known for its humectant activities id as a pH control agent. Its use as an additive in baked oducts at levels of 1.5-2% was reported as early as 1969 5). The salt is also approved by the USDA as a flavoring ent in meat and poultry products at a level of 2% based its solid weight. In addition to the meat flavor enhancement, the humectant properties contribute to the water-ling capacity and increase the cooking yields. Appli-ons recommended by manufacturers of lactates include tion of 2-3%, based on the finished product weight, to sausage and a variety of cooked meat and poultry ıcts (*8*).

The antimicrobial activity of lactic acid, from which ılt is derived, is well documented and is associated eduction of pH to levels below the growth of a large r of bacteria. Antimicrobial effects are attributed also ıte, as evidenced by product information supplied by cturers (*4*). However, published studies on the an-bial activity of lactate salts in meat or other foods ted. Angersbach (*2*) reported that sodium lactate at ations of up to 7% in meat resulted in complete n of *Bacillus* spp., including *B. cereus*, *B. subtilis*, ans. Decreased growth of bacterial species was dry cured ham formulated with sodium lactate tobacilli, micrococci, and "Achromobacter" were affected. Debevere (*6,7*) studied effects of lactate on water activity and shelf life of refrigerated vacuum-packaged pork liver pâté. Addition of 2% sodium lactate decreased the water activity and inhibited growth of lactic acid bacteria that are normally responsible for spoilage of the product. Growth of *Clostridium botulinum* was delayed in fish, chicken, and turkey treated with 1.5 to 3.5% sodium lactate (*1*). In addition, delayed *C. botulinum* toxin production by sodium lactate was reported in turkey products (*13*). In the latter study, vacuum-packaged comminuted raw turkey that contained 2-3.5% sodium lactate showed delayed toxin formation after inoculation with *C. botulinum*, and the antibotulinal effect was concentration-dependent. Effects in vacuum-packaged beef roasts injected with a solution of sodium chloride, tripolyphosphate, and various levels of lactate before cooking were reported recently (*9,14*). Data showed delayed microbial growth with increasing levels of sodium lactate to 4% during storage at 0°C, while a concentration of up to 3% was judged optimal for overall beneficial effects, which also included cooking yield, flavor, and color. The microflora after 84 d of storage became more uniform, consisting predominantly of hetero- and homofermentative *Lactobacillus* spp. While it has been suggested that growth inhibition by lactates is affected irrespective of the microbial types (*5*), currently published data are insufficient to conclude whether lactate is equally effective in controlling spoilage and pathogenic microorganisms, or whether it favors growth of certain organisms over that of others, bringing about flora alteration. Product information by manufacturers refers to proven effective inhibition of *Listeria* and *Salmonella* spp. (*4*), but no studies on the effect of lactate on *Listeria monocytogenes* (LM) appear to have been published.

The limited reports on the antibacterial activity of lactates raised the interest to study their effects on growth of LM. The purpose of the present study was to investigate the antilisterial effects of sodium lactate in laboratory media and in meat model systems. Since elevated sodium levels in meat or poultry may result from the combination of sodium lactate with sodium chloride, the antimicrobial effects of potassium lactate were further examined and compared to those of the sodium salt. In addition, the combined effects of lactate, sodium chloride, and nitrite were investigated.

Bacterial cultures

LM strains Scott A, associated with the 1983 milk-borne listeriosis outbreak, Brie-1, a Brie cheese isolate, and V-7, originally isolated from milk, were used in the studies in broth, while the former was used in studies in meat. Stock cultures of the strains were maintained on tryptic soy agar (TSA) at 5°C. Inocula for the experiments were prepared in tryptic soy broth tubes (TSB, Difco Labs, Detroit, MI), incubated at 35°C for 24 h. Cultures were appropriately diluted in TSB so that the initial CFU/ml or g was about 10^3.

Studies in broth

TSB tubes containing increasing concentrations to 10.5% by weight of sodium or potassium lactate (NaL or KL, 60% aqueous solution, Food Grade, Wilke International, Inc., Overland Park, KS) were prepared and sterilized. After cooling to room temperature, the broth was inoculated with 0.1 ml of the test organisms and incubated at 35°C. Initial cell numbers, and those during incubation, were determined using prepoured TSA plates and a spiral plater (Spiral System, Inc., Bethesda, MD). All sample dilutions were made in 0.1% sterile peptone water and colonies were enumerated after incubation for 48 h at 35°C. All tests were run in duplicate and repeated twice.

Studies in meat model systems

Foods used in the study were comminuted beef or chicken with added broth (Baby food, H.J. Heinz Co., Pittsburgh, PA). Their composition is shown in Table 1. The effects studied included those of the following ingredients and concentrations, alone or in combination : NaL or KL, 2.6 and 4%; NaCl, 2 and 3%; and KNO_2, 140 ppm. After adding the test compounds to the food, the contents were thoroughly mixed and 11-g samples were dispensed into 50-ml autoclavable plastic beakers. The beakers were covered and sterilized (121°C, 15 min). After cooling to room temperature, the samples were inoculated with LM strain Scott A. Chicken and beef alone, containing levels of water equal ' ose added from the aqueous solutions of the lactates, served a ntrol. Incubation was at 5, 20, and 35°C. Cell numbers were determined immediately after sample inoculation and at time intervals during storage. For the determination, samples were diluted 1:10 with peptone water in a sterile stomacher bag and macerated for 2 min using Model 400 Stomach (Dynatech Laboratories, Inc., Alexandria, VA). The suspension (0.1 ml) was either directly spread on prepoured plates or further diluted and plated using the spiral plater. Incubation and enumeration were as described before. Two replicates were tested for each combination of compounds and storage time, and mean values calculated.

Determination of pH

The pH of representative samples containing the tested concentrations of NaL or KL was determined after sterilization using Orion pH meter.

BLE 1. *Analysis of the meat products.*

ponent	Beef %	Chicken %
er	77.4	75.4
ein	14.0	13.7
	7.5	10.1
	0.7	0.9
hydrate	*	*

Heinz, 1989.
o si ficant amount.

RESULTS

The effects of increasing NaL concentrations on growth of three LM strains are summarized in Table 2. Inocula (log_{10} CFU/ml) in these experiments were 3.5-4.2. While cell multiplication occurred even in the presence of the highest NaL concentration, the extent of bacterial growth decreased with increase of the salt content, and all three strains behaved in a similar manner. Partial growth curves for strain Scott A in TSB alone and in combination with NaL are shown in Fig. 1. Cell numbers generally reached a maximum after 24 h of incubation at 35°C and declined after 48 h. Reduced growth after 24 h was seen only by the addition of 7.8% NaL, and these effects persisted throughout the incubation period.

TABLE 2. *Effects of sodium lactate on cell numbers of* Listeria monocytogenes *strains.*

Strain	NaL in TSB (% by weight)				
	0	2.6	5.2	7.8	10.4
Scott A	9.48	9.40	8.69	7.69	5.62
Brie-1	9.18	9.00	8.98	7.97	5.00
V-7	9.45	8.93	8.54	8.15	5.56

Log_{10} CFU/ml after 24 h at 35°C. Initial counts were: Scott A, 4.2; Brie-1, 3.74; V-7, 3.48.

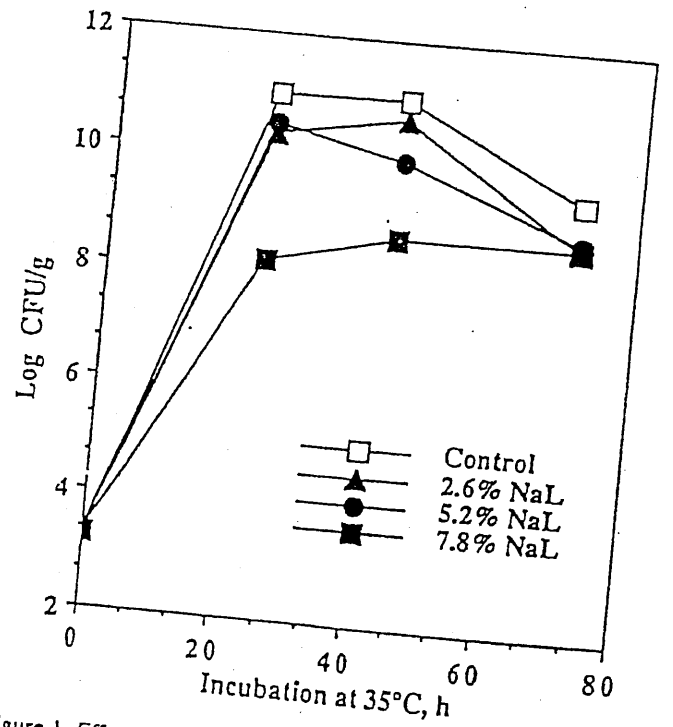


Figure 1. *Effect of sodium lactate on growth of* L. monocytogenes *strain Scott A in trypticase soy broth at 35°C.*

Preliminary examination of effects of two lactate concentrations on growth of LM in refrigerated beef confirmed growth suppression. Examination of growth of strain Scott A in meat alone and with added KL during refrigeration for 30 d showed effects with 2.6% of the salt, and these were enhanced by the addition of 4% (data not shown). This latter concentration was used for further studies.

Growth curves for strain Scott A in beef and chicken

samples exceeded 10^9 CFU/g. Growth was reduced in all lactate containing samples, but effects were small in chicken and more pronounced in beef.

Effects during storage at 20°C for 8 d are shown in Fig. 3. Maximum cell numbers exceeded 10^9 as before, and although growth was very similar in chicken and beef alone, the growth suppression effects were more pronounced in beef. Suppressed growth was seen also during refrigeration at 5°C for 21 d (Fig. 4). While maximum cell numbers in control samples were ca. 10^9 CFU/g, LM grew faster in chicken than in beef. As before, the lactates were less

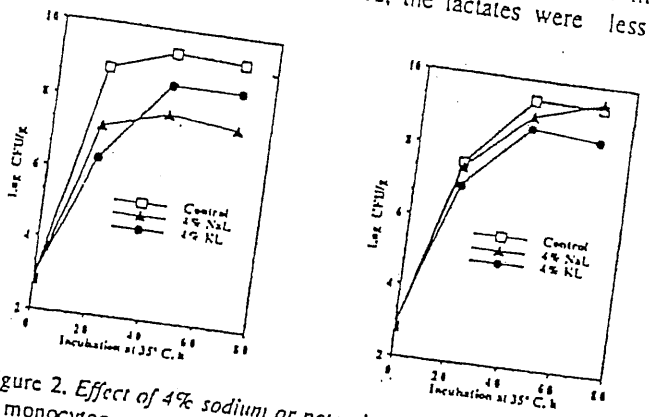
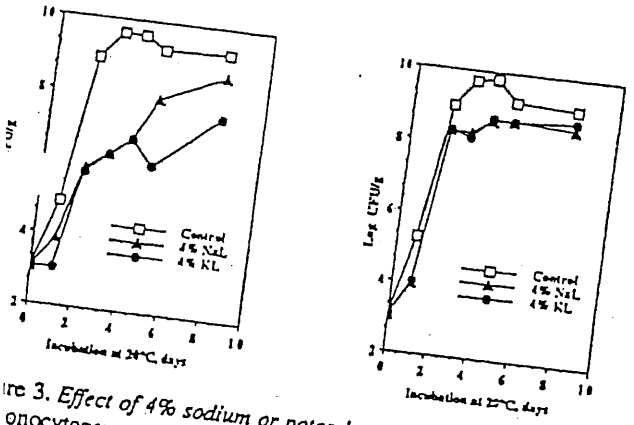


Figure 2. *Effect of 4% sodium or potassium lactate on growth of L. monocytogenes strain Scott A in beef (left) and chicken (right) during incubation at 35°C.*



ire 3. *Effect of 4% sodium or potassium lactate on growth of onocytogenes strain Scott A in beef (left) and chicken (right) 'g incubation at 20°C.*

ive inhibitors in chicken than in beef, where no h was visible until the 10th d of storage. Suppressed l persisted even after 21 d, when populations were 2- ycles lower than in control medium. In contrast, by of this refrigeration period, cell numbers in treated reached or approached those in lactate free samples. ce NaCl is generally present in cooked meat prod- effect of 2 and 3% additions to beef was investi- ne and in combination with lactate. The lower salt ition had negligible effects on growth (data not Growth curves for LM in beef containing 3% KL, and the combination of the two during 5°C are shown in Fig. 5. NaCl caused some growth reduction at this temperature, but a very small difference was discerned in growth pattern of the organism in control and NaCl containing samples at 20 or 35°C. The effects of KL alone or in combination with NaCl were identical during the first 3 weeks of storage at 5°C, but on further storage the organism grew at a slower rate in the presence of the two salts. Similar results were seen also in the higher incubation temperatures (data not shown).

The effects of potassium nitrite (140 ppm) alone, and in combination with lactate, were examined during storage at 20°C (Fig.6) and 5°C (Fig. 7). The presence of nitrite in beef did not alter the growth pattern of LM. Likewise, the combination of nitrite with either NaL or KL (4%) did not enhance the inhibitory effects of the lactates.

NaL and KL additions to TSB produced small pH lowering effects. TSB alone had a pH of 7.23, and addition of 10% lactate lowered the broth pH to 6.7. There was no difference in pH of the meats alone and with 4% added lactate; beef pH was 6.27, and chicken pH was 6.5.

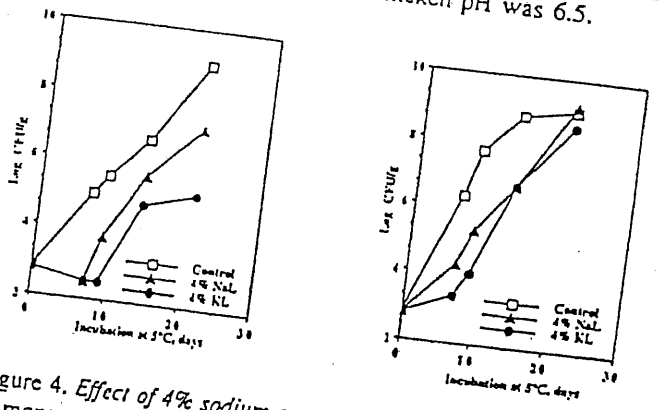


Figure 4. *Effect of 4% sodium or potassium lactate on growth of L. monocytogenes strain Scott A in beef (left) and chicken (right) during incubation at 5°C.*

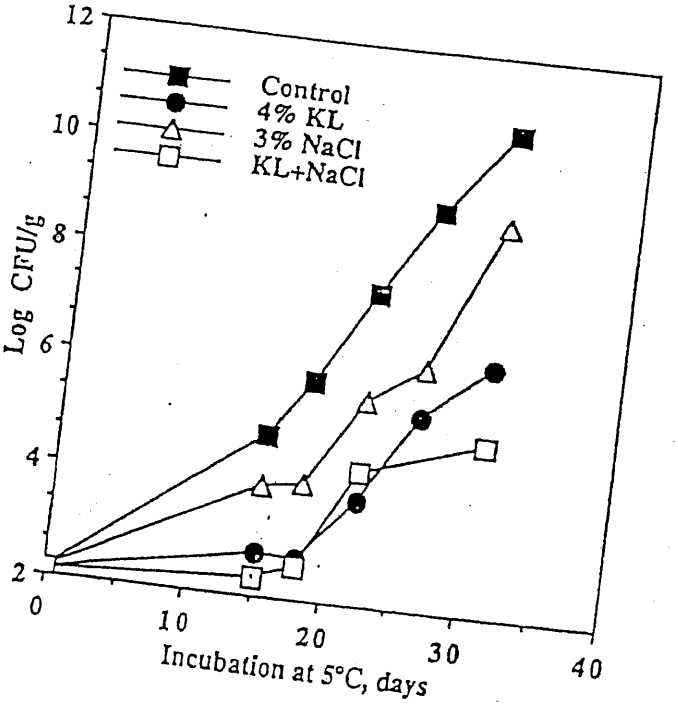


Figure 5. *Effect of 4% potassium lactate, 3% NaCl, and their combination on growth of L. monocytogenes strain Scott A in beef during storage at 5°C.*

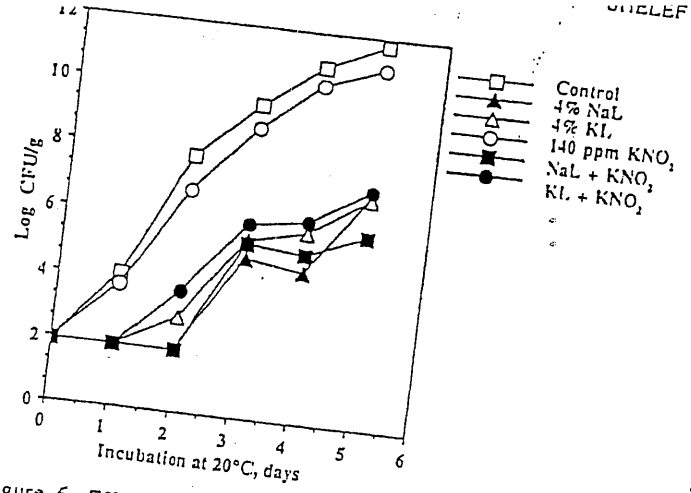


Figure 6. *Effect of 4% sodium or potassium lactate, 140 ppm potassium nitrite, and their combination on growth of* L. monocytogenes *strain Scott A in beef during incubation at 20°C.*

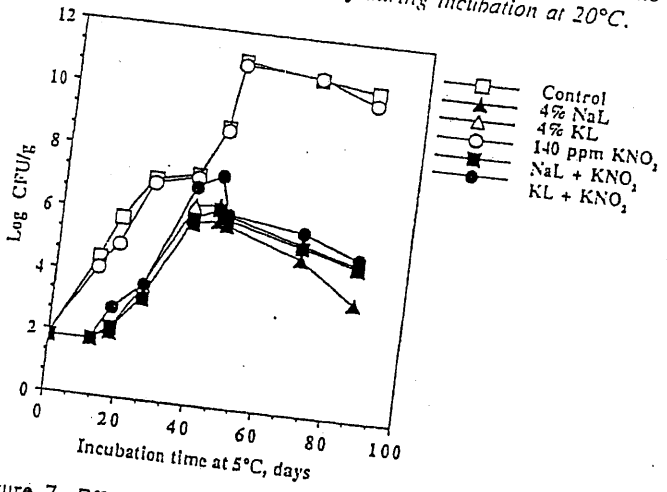


Figure 7. *Effect of 4% sodium or potassium lactate, 140 ppm potassium nitrite, and their combinations on growth of* L. monocytogenes *strain Scott A in beef during storage at 5°C.*

DISCUSSION

The meat products used in this study were selected for eliminary evaluation of antilisterial effects of lactates. hey are convenient to use and, being free of additives, ey lend themselves to evaluation of effects of meat oducts ingredients.

The inoculum of LM used in the experiments was roximately 10^3 CFU/g, substantially higher than contination levels reported in fresh or processed meats. ough it is possible that the antilisterial efficiency of tes will be higher at lower contamination levels, this not be the case if small numbers of listeriae are found presence of other bacteria, particularly if the effect of es is nonspecific with regard to genus and species. omparison between results obtained by the use of the K salts revealed no difference, confirming that the lts are equal in their effect. Partial replacement of the with the K salt could be considered in order to limit io: meat products if growth suppression of other l species is also equally affected by either salt, and product flavor is acceptable.

Sodium chloride or potassium nitrite at concentrations permitted in foods did not affect growth of LM, nor did they enhance the effects of lactate. These observations confirm previous published data (*11*) on resistance of LM to salt and nitrites in meat products.

With regard to the mode of action, Hammer and Wirth (*10*) showed that sodium lactate can lower the water activity in cooked liver sausage, and similar effects were reported also in cooked ham (*3*). In a study by Debevere (*7*), using vacuum-packaged coarse pork liver paté with 50% H_2O, the water activity of 0.959 decreased to 0.945 by the addition of 2% NaL, and counts of lactic acid bacteria after 6 weeks at 36°C were three-log cycles lower than in control. However, similar lowering of the water activity, achieved by additions of NaCl, failed to affect microbial growth. In the present study, growth suppression by the addition of 4% lactate was higher in beef than in broth. This is in contrast to the more pronounced inhibitory effects normally observed in tests conducted in laboratory media, suggesting that restriction of free water may indeed be a contributing factor. Since the comminuted beef and chicken used in the present study contained substantially higher moisture content (75-77%) than most meat products, the effects of lactate may be enhanced in those with lower a_w. The effect of a_w reduction on bacterial growth is characterized by extended lag phase and suppressed logarithmic growth rate (*16*), and such growth patterns were observed for LM in lactate containing beef, particularly during refrigerated storage. Growth curves for exterior and interior aerobic plate counts in cooked beef roasts containing 4% NaL during storage for 84 d at 0°C also had similar characteristic shapes (*14*).

It was suggested that a mechanism other than lowering of water activity is responsible for the antibacterial effects (*3*), and that inhibitory effects result from lactate transport into the bacterial cell. Maas et al. (*13*) proposed that delay of botulinal toxin production may be caused by a shift in the pyruvate to lactate reaction by the high levels of lactate ions, thereby inhibiting a major anaerobic energy metabolism pathway essential for growth. The effect of high levels of extracellular lactate on *Listeria* cells is not known at this time.

Results indicated growth suppression of LM by the lactates for one week or longer during refrigeration temperatures and higher sensitivity of the organism in beef than in chicken. The fat content is higher in the latter (10.1% vs. 7.5% in beef), and this might have provided protection to the cells. Addition of Na or K lactate to the foods, unlike that of lactic acid, did not influence their pH.

Research on the effect of lactate on LM alone and in the presence of other foodborne bacteria is needed in order to determine if the effects are species-specific. Such information will enable to assess the benefits of this compound as an antimicrobial in meat products. The present studies do not confirm manufacturers' claim to the effectiveness of lactate at allowable concentrations in products containing ca. 75% water. Further studies are in progress to determine antilisterial activities of lactates in products with reduced moisture and the influence of lactates on a

REFERENCES

1. Anders, R.J., J.G. Cerveny, and A.L. Milkowski 1989. Method for delaying *Clostridium botulinum* growth in fish and poultry. U.S. Patents #4,798,729. Jan. 17, and #4,888,191. Dec 19.
2. Angersbach, H. 1971. Systematic microbiological and technological investigation into improving the quality of foods of animal origin. III. Influencing the growth of three *Bacillus* types by means of sodium chloride, sodium acetate, sodium diacetate, sodium citrate, sodium lactate, and sodium tartrate. Fleischwirtsch. 51(2):205-209.
3. Anonymous. 1988. A meaty problem solved. Food Processing, December. p. 9.
4. Anonymous. 1989. Application of sodium lactate and potassium lactate in processed meat and poultry. Wilke International, Inc., Overland Park, KA.
5. Bacus, J. 1988. Microbial control methods in fresh and processed meats. Recip. Meat Conf. Proc., Vol. 41. p. 7.
6. Debevere, J.M. 1987. The use of buffered acidulant systems to improve the microbiological stability of acid foods. Food Microbiol. 4:105-113.
7. Debevere, J.M. 1989. Extended shelf-life from lowered A_w and growth inhibition of lactic acid bacteria by sodium lactate. Fleischwirtsch. 69:223-227.
8. Duxbury, D.D. 1988. Natural sodium lactate extends shelf life of whole and ground meats. Food Processing, January. p. 91.
9. Duxbury, D.D. 1990. Sodium lactate extends shelf life, improves flavor of cooked beef. Food Processing, April. pp. 46-47.
10. Hammer, G.F., and F. Wirth. 1985.. Diminution of water activity (a_w) in liver sausage. Proc. Eur. Meet. Res. Workers, No. 31, 6.46. p. 610.
11. Junttila, J., J. Hirn, and E. Nurmi. 1989. Effect of different levels of nitrite and nitrate on the survival of *Listeria monocytogenes* during the manufacture of fermented sausage. J. Food Prot. 52:158-161.
12. Krol, B. 1972. Meat products. Voedingsmiddelen-Technologie 3:157-158.
13. Mass, M.R., K.A. Glass, and M.P. Doyle. 1989. Sodium lactate delays toxin production by *Clostridium botulinum* in cook-in-bag turkey products. Appl. Environ. Microbiol. 55:2226-2229.
14. Papadopoulos, L.S., R.K. Miller, G.R. Acuff, C. Vanderzant, and J.T. Keaton. 1989. The effect of sodium lactate on cooked beef shelf-life, chemical attributes, and sensory properties. A final report to the Beef Industry Council, National Live Stock and Meat Board. Texas A&M University, College Station.
15. Reid, T.F. 1969. Lactic acid and lactates in food products. Food Manufacture 44(10):54-55.
16. Troller, J.A. 1983. Sanitation in food processing. Academic Press, Inc., New York. p. 127.

...04, No. 5, 2001, Pages 640–644
...ernational Association for Food Protection

Enhanced Inhibition of *Listeria monocytogenes* and *Salmonella* Enteritidis in Meat by Combinations of Sodium Lactate and Diacetate

EVELYNE MBANDI AND LEORA A. SHELEF*

Department of Nutrition and Food Science, Wayne State University, Detroit, Michigan 48202, USA

MS 00-256: Received 24 July 2000/Accepted 18 October 2000

ABSTRACT

The antimicrobial activities of sodium lactate (SL) and sodium acetate (SA) are well documented, but there is limited information on the effect of their combination or of the combination of SL and sodium diacetate (SDA) on survival and growth of *Listeria monocytogenes* and salmonellae in meat. Effects of SL (1.8 and 2.5%), SDA (0.1 and 0.2%), or SA (0.2%) and their combinations on the behavior of *L. monocytogenes* and *Salmonella enterica* serovar Enteritidis were investigated in sterile comminuted beef (pH 6.3, 79% moisture) during storage at 5 and 10°C. Although *L. monocytogenes* grew faster than *Salmonella* Enteritidis in control samples at 10°C, numbers of both pathogens increased from 3.5 to approximately 8.0 log CFU/g after 20 days. SL (1.8%) decreased the growth rate of both *L. monocytogenes* and *Salmonella* Enteritidis. SDA (0.2%) was more effective than SL in decreasing the growth rate of *L. monocytogenes*, and it caused a more than 1 log CFU/g decline in initial numbers of *Salmonella* Enteritidis during storage for 25 days at 10°C. Synergy was observed by combinations of SL and SDA. Combinations of 2.5% SL and 0.2% SDA were bacteriostatic to *L. monocytogenes* and bactericidal to *Salmonella* Enteritidis after 20 days at 10°C. At 5°C, a listeriostatic effect was produced by 1.8% SL + 0.1% SDA, whereas numbers of *Salmonella* Enteritidis were less than 10 cells/g after refrigeration for 30 days. Although SA was consistently and significantly less inhibitory than SDA, its mixtures with SL also demonstrated synergistic activity against both pathogens. Combinations of 2.5% SL and 0.2% SDA can be expected to greatly enhance the safety of refrigerated and temperature-abused ready-to-eat meats.

Foodborne listeriosis, caused by *Listeria monocytoge-*
ıes, continues to be of major concern to the food industry
nd general public because of its high mortality rate of
ıor... an 25% and its economic impact *(7, 11, 12, 24, 26)*.
utbreaks have been associated with ready-to-eat foods
ch as coleslaw, milk, soft cheese, and meats *(7, 11, 12,*
). Salmonellosis is another commonly reported foodborne
ection, with *Salmonella enterica* serotype Enteritidis be-
the most frequently identified in foodborne infections
ıe United States *(13, 23)*. Foods implicated in salmo-
ısis include eggs, poultry, meat, and raw produce *(4,*
3, 23).

Ensuring the microbial safety and shelf life of foods
ds on minimizing the initial level of microbial con-
ation, preventing or controlling the level of microbial
, or destroying microbial populations. However, de-
ood safety regulations and Hazard Analysis Critical
Points practices, the incidence of foodborne dis-
nd particularly of listeriosis, has been increasing in
strialized world in the last decade *(6, 24)*.
anic acids such as lactic and acetic acids are known
antimicrobial effects in foods. The mechanism of
has been attributed to entry of the undissociated
ıe weak lipophilic acids into the microbial cells,
n within the cells, and acidification of the cell interior *(8, 16)*. The salts of these two acids are generally recognized as safe and are approved as direct ingredients for use in foods. The sodium salt of lactic acid is used as a humectant and flavor enhancer in meat and poultry products and contributes to increased cooking yields and water-holding capacity *(19)*. Levels of 2% (3.3% of the available 60% solution) have been recommended in meat and poultry products *(19)*, although higher concentrations are now deemed more effective *(25)*. Sodium lactate (SL) (2 to 3%) has been shown to control growth of *L. monocytogenes (2, 21)* and *Listeria innocua (9)* in meat, with minimal effect on pH and sensory characteristics of the products. Sodium diacetate (SDA) is a flavoring agent and an antimicrobial, and levels of 0.1 to 0.2% are recommended for use in meat products *(3)*. At concentrations of 0.1 to 0.3%, SDA has been shown to control growth of *L. monocytogenes* in meat *(18)*. Shelef and Addala *(20)* reported that SDA added to brain heart infusion (BHI) broth delayed growth of *L. monocytogenes*, and the effect was enhanced at a lower storage temperature. They further confirmed that concentration of 0.1 or 0.3% SDA suppressed growth of *Listeria* in fresh meat *(20)*.

Synergistic effects of mixtures of lactic and acetic acids were reported in studies with foodborne pathogens such as *Salmonella* Enteritidis and *Escherichia coli (1, 15)*. However, there is limited information on synergistic effects of salts of these acids on foodborne pathogens at or near pH

correspondence. Tel: 313-577-2998; Fax: 313-577-8616;
ef@sun.science.wayne.edu.

6. The purpose of the present study was to investigate the effect of SL, SDA, or sodium acetate (SA) and their combinations on the fate of *L. monocytogenes* and *Salmonella* Enteritidis in a sterile comminuted beef model system during storage at 5 and 10°C. The behavior of each of these pathogens in the meat, alone, or in combination was further compared.

MATERIALS AND METHODS

Microorganisms. *L. monocytogenes* Scott A serotype 4b, originally obtained from M. P. Doyle, University of Georgia, and *Salmonella enterica* serotype Enteritidis ATCC 13076 were used in the study. The cultures were maintained on BHI agar slants and grown in 5 ml of BHI broth at 35°C for 18 to 24 h before use. Serial dilutions of the fresh cultures were carried out in 0.1% peptone water (PW).

Meat and chemicals. A salt-free sterile comminuted beef emulsion, 79% moisture, 5% fat (Gerber, Fremont, Mich.), was used in the study. SL was obtained from PURAC America Inc. (Lincolnshire, Ill.); SA and SDA were from Niacet (Niagara Falls, N.Y.). All salts were food grade.

Preparation and inoculation of samples. Salt levels (% by weight) added to the beef were as follows: SL, 1.8 and 2.5%; SDA, 0.1 and 0.2%; or SA, 0.2%; and their combinations. The salts, in concentrated aqueous solutions, were thoroughly mixed into the meat (250-g batches). Equal amounts of sterile water (1.5 ml per 100 g) were added to the untreated meat that served as control. Samples (11 g) were dispensed into plastic cups (30-ml volume), tightly covered with aluminum foil, and sterilized for 15 min at 121°C. *L. monocytogenes*, *Salmonella* Enteritidis, or their combination (approximately 4 log CFU in 0.1 ml of PW) was dded to each of the cooled samples and the content thoroughly nixed. Samples were stored at 5 or 10°C.

Enumeration of microorganisms and pH measurement. Cells were enumerated in the meat samples immediately after inoculation and at 5-day intervals until levels of approximately 8 log CFU/g were reached or for 25 days at 10°C and 30 days at 5°C. Samples (11 g), in duplicate, were combined with sterile PW (99 ml) in stomacher bags, and the contents blended for 2 min (Stomacher 400, Seward Medical, London, England). Appropriate dilutions in PW were plated in duplicate on prepoured selective agar plates (PALCAM and XLT4 for *L. monocytogenes* and *Salmonella* Enteritidis, respectively). Colonies were counted after incubation of the plates at 35°C for 24 to 48 h. Meat pH was measured initially and at each sampling time by directly inserting the pH electrode (model 720A, Orion Research Inc., Boston, Mass.) into the meat homogenates (1:10 dilution in PW). This procedure provided readings comparable with those obtained by direct measurements of the meat pH. All microbiological media were from Difco Laboratories, Detroit, Mich.

Preenrichment of samples stored at 5°C. For the detection of surviving *Salmonella* Enteritidis, meat samples were preenriched in *Salmonella* selective broth as described by Peng and Shaw *(14)*. The medium consists of Proteose Peptone no. 3, yeast extract, sodium chloride, ferric ammonium citrate, sodium thiosulfate, D-dulcitol and D-xylose, lysine and ornithine, novobiocin, and mannitol. Presence of salmonellae in the meat samples is identified by black coloration of the medium during incubation in the incubator instrument at 42°C *(14)*.

Data analysis. Each trial was repeated twice, and duplicate samples were tested at each sampling time. All data were analyzed by SPSS computer program, version 10.0 *(22)*. Statistical methods included independent sample *t* test and one-way analysis of variance. Significance was based on a probability level of 0.05 ($P < 0.05$).

RESULTS

The initial *L. monocytogenes* and *Salmonella* Enteritidis populations in the meat samples were approximately 3.5 log CFU/g. These populations were selected so that increases or declines in counts over time could be measured. Although *L. monocytogenes* grew at a faster rate than *Salmonella* Enteritidis at 10°C, concentrations of approximately 8 log CFU/g of both pathogens were reached by day 20 in the untreated samples. The growth pattern of each pathogen was similar whether inoculated into the meat alone or in combination with the other. *L. monocytogenes* in the untreated meat reached 8 log CFU/g after 30 days at 5°C, whereas *Salmonella* Enteritidis declined to undetectable numbers on XLT4 agar plates.

The meat pH (6.3) was not affected by the addition of SL and SA and was slightly reduced to 5.9 after addition of SDA ($P > 0.05$). A small pH increase of 0.2 to 0.3 pH units was observed in both treated and untreated samples during storage for 20 days at 10°C, and no change was observed in the refrigerated samples. Hence, the pH range of the meat throughout the study remained well above the minimum required for growth of both pathogens.

SL (1.8 and 2.5%), SDA (0.1 and 0.2%), and SA (0.2%) caused a decrease in growth rate of *L. monocytogenes* during storage at 10°C, but cell numbers were not significantly different from those in control samples after 20 days. The behavior of *L. monocytogenes* in meat treated with 2.5% SL, 0.2% SA, or 0.2% SDA and in untreated meat is illustrated in Figure 1A. Combinations of SL (2.5%) and SA or SDA (0.2%), however, were more inhibitory ($P < 0.05$), and the combination of SL (2.5%) and SDA (0.2%) was listeriostatic (Fig. 1B).

Salmonella Enteritidis was more sensitive than *L. monocytogenes* to each of the salts. Concentrations of 0.2% SDA or SA inhibited growth of the organism at 10°C (Fig. 2A). Enhanced inhibition was observed by the combination of 1.8% SL and 0.1% SDA (data not shown). Combinations of 1.8% SL with 0.2% SDA or 2.5% SL with 0.2% SA were bacteriostatic, and the combination of 2.5% SL and 0.2% SDA was bactericidal (Fig. 2B).

The behavior of *L. monocytogenes* in the meat emulsion during storage at 5°C for 30 days is illustrated in Figure 3. Decreased growth rate showed in samples treated with SL (1.8 and 2.5%) and SDA (0.1%), whereas treatments with the combinations of these salt concentrations were listeriostatic. No *Salmonella* Enteritidis colonies could be recovered on XLT4 agar plates from any of the beef samples after storage for 30 days. However, preenrichment for 24 h at 42°C resulted in black coloration of the broth for each of the treatments, indicating survival of very low numbers of salmonellae in each of the refrigerated treatments.

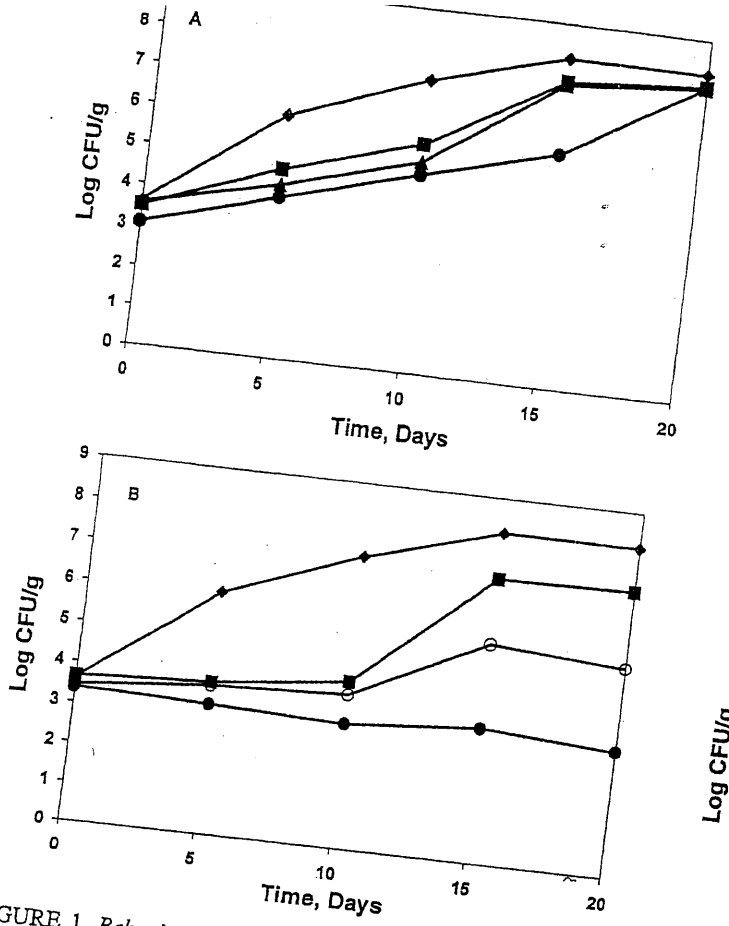


FIGURE 1. *Behavior of* L. monocytogenes *in meat emulsion at 10°C. (A) Effect of single salts.* ◆, *control;* ■, *2.5% SL;* ▲, *0.2% SA;* ●, *0.2% SDA. (B) Effect of salt combinations.* ◆, *control;* ■, *0.2% SA + 2.5% SL;* ○, *0.1% SDA + 2.5% SL;* ●, *0.2% SDA + 2.5% SL. Each value is the mean of two tests run in duplicate.*

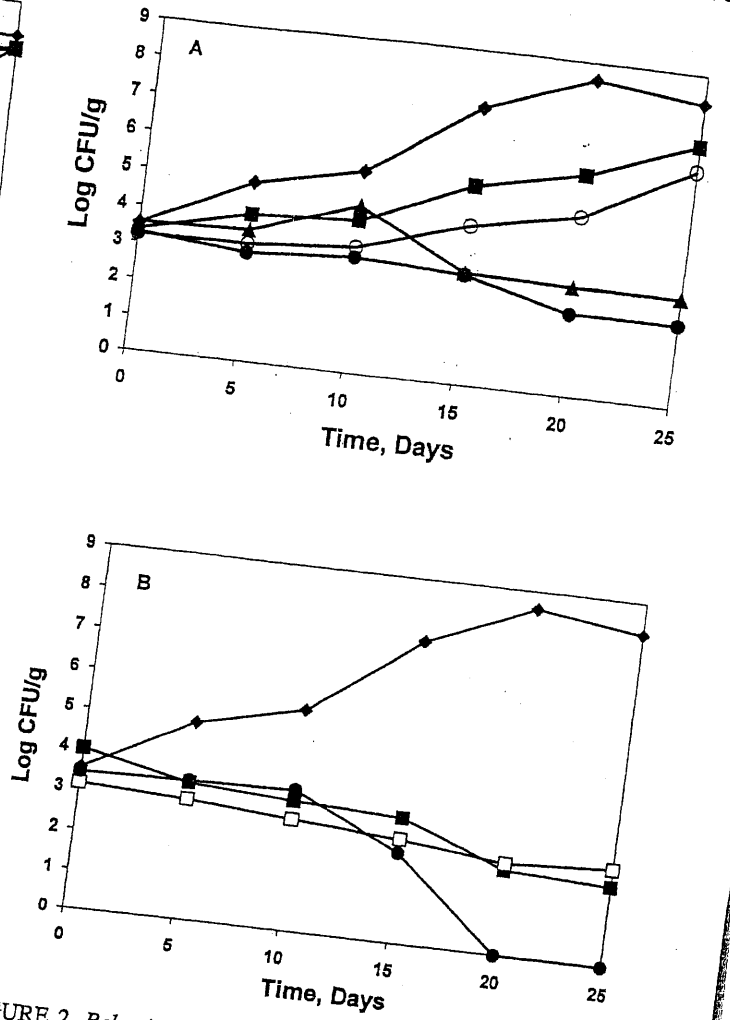


FIGURE 2. *Behavior of* Salmonella *Enteritidis in meat emulsion at 10°C. (A) Effect of single salts.* ◆, *control;* ■, *2.5% SL;* ▲, *0.2% SA;* ○, *0.1% SDA;* ●, *0.2% SDA. (B) Effect of salt combinations.* ◆, *control;* ■, *0.2% SA + 2.5% SL;* □, *0.1% SDA + 2.5% SL;* ●, *0.2% SDA + 2.5% SL. Each value is the mean of two tests run in duplicate.*

DISCUSSION

The addition of SL to meat emulsion caused a decrease 1 the growth rate of *L. monocytogenes*. Populations of 7 'g CFU/g or higher were reached in meat treated with 5% of the salt after 15 days at 10°C and after 30 days at C (Figs. 1A and 3). Previous work in our laboratory owed that a higher concentration (4% SL) suppressed *L. nocytogenes* growth in sterile comminuted chicken held and 20°C *(21)*. *Salmonella* Enteritidis was more sen- e to 2.5% SL, with populations of 7.1 log CFU/g hed after 25 days at 10°C (Fig. 2A). Gram-negative eria have shown greater sensitivity to organic acids and salts than gram-positive bacteria *(20)*.

DA is a dry salt composed of SA and acetic acid at molar concentration. This compound was consistently effective than SA, the salt of acetic acid, in inhibiting *ocytogenes* ($P < 0.05$). It was also a more effective erial agent than SL at the concentrations used in this $P < 0.05$). Concentrations of 21 mM (0.3%) and 28 4%) SDA have been shown to control growth of in ground beef and ground beef slurry during stor- °C *(20)*.

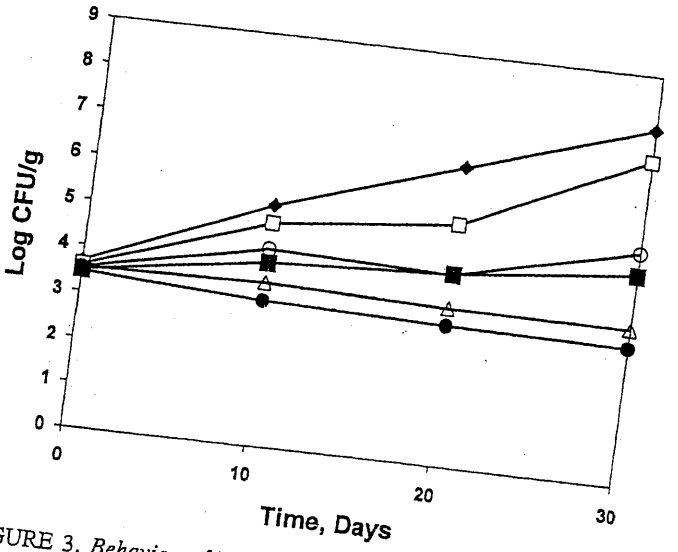


FIGURE 3. *Behavior of* L. monocytogenes *in meat emulsion at 5°C.* ◆, *control;* □, *1.8% SL;* ■, *2.5% SL;* ○, *0.1% SDA;* △, *1.8% SL + 0.1% SDA;* ●, *2.5% SL + 0.1% SDA. Each value is the mean of two tests run in duplicate.*

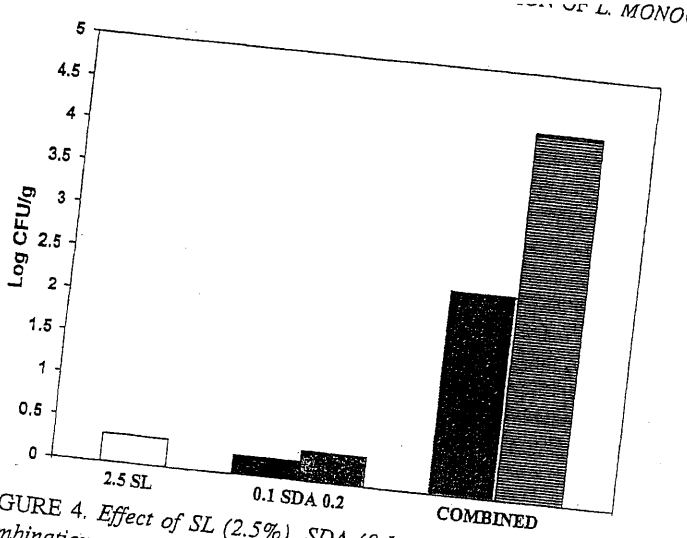


FIGURE 4. *Effect of SL (2.5%), SDA (0.1 and 0.2%), and their combination on the viability of* L. monocytogenes *in meat. The data represent the difference between populations in the untreated meat and in the respective treatments after 20 days at 10°C.*

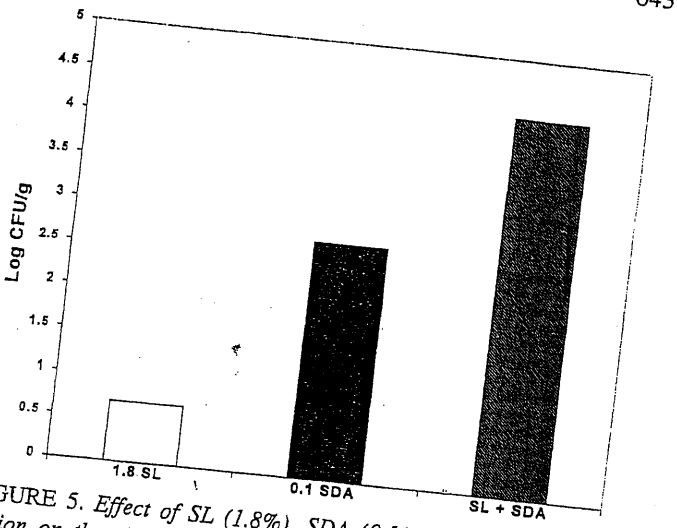


FIGURE 5. *Effect of SL (1.8%), SDA (0.1%), and their combination on the viability of* L. monocytogenes *in meat. The data represent the difference between populations in the untreated meat and in the respective treatments after 30 days at 5°C.*

At 10°C, each of the tested salts proved ineffective in inhibiting growth of *L. monocytogenes* during storage. Although the higher concentration of SDA (0.2%) was most effective, *L. monocytogenes* populations were not significantly different from those in control and in the other salt treatments after storage for 20 days (Fig. 1A). When SL was combined with either SA or SDA, enhanced inhibition of *L. monocytogenes* was observed. Figure 4 illustrates the synergy for 2.5% SL and either 0.1 or 0.2% SDA. The bars represent the difference between log CFU/g in controls and in the respective treatments after 20 days at 10°C. Although the effects of 0.1 and 0.2% SDA alone were not signifi-
tly different ($P > 0.05$), their combination with 2.5%
SL dramatically enhanced the antilisterial effect. The re-
duction of log CFU/g was 3.7 times (2.5% SL + 0.1%
SDA) and 4.5 times (2.5% SL + 0.2% SDA) larger than
he sum of reductions obtained with the single salts. En-
anced antilisterial effects were observed by the salts dur-
ng storage at 5°C, and the combination of 1.8% SL and
.1% SDA was listeriostatic during storage for 30 days.
igher concentrations (2.5% SL + 0.1 or 0.2% SDA) were
ly slightly more inhibitory. Used together, the effect of
3% SL and 0.1% SDA was 1.3 times higher than the sum
reductions obtained with the single salts (Fig. 5). Syn-
y, although less pronounced, was also observed by the
ibination of SL and SA. Schlyter et al. *(18)* reported
centrations of 0.1 or 0.3% SDA with 2.5% SL to be
e effective in inhibiting growth of *L. monocytogenes* at
d 25°C compared with 0.1 or 0.3% SDA alone.

Salmonella Enteritidis was more sensitive than *L. mon-*
genes to all three salts tested during storage at 10°C,
imilar to the effects on *L. monocytogenes*, inhibition
DA (0.2%) > SA (0.2%) > SL (2.5%).

t a higher concentration of 0.2%, SA had a bacteri-
effect, whereas SDA caused a slow decline in the
cell numbers after 20 days of storage (Fig. 2A).
of *Salmonella* Enteritidis was inhibited by the com-
SL and SDA, and no colonies could be recov-
ar plates from meat treated with 2.5% SL and 0.2% SDA after 20 days at 10°C. However, preenrichment of these samples indicated survival of *Salmonella* Enteritidis cells. Survival of *Salmonella* Enteritidis was similarly detected in each of the treatments stored at 5°C.

SDA (0.1%) is used as a flavoring agent and antimicrobial in meat. Recently, the Food Safety Inspection Service, U.S. Department of Agriculture, approved a higher SDA concentration (0.25%) to inhibit growth of *L. monocytogenes (25)*. The use of 4.8% SL as a flavoring agent and as a means of inhibiting certain pathogens in cooked meat and poultry products was also approved. However, the agency stated that no evidence was available for the efficacy of these high concentrations of the salts to inhibit pathogens. Our studies demonstrate that the combination of SL and SDA, at concentrations lower than the maximum approved for use and well within those considered acceptable organoleptically, was bactericidal to *Salmonella* Enteritidis at 10°C, bacteriostatic to *L. monocytogenes* at 10°C, and more inhibitory at refrigeration temperatures.

The inhibitory effects of the salts used in this study are not dependent on pH reduction, since the meat pH remained at approximately 6 throughout the storage periods. Therefore, other mechanisms, different from those proposed for their acids *(8, 16)*, are responsible for the inhibitory effects of these salts. Although the mechanism of synergy of the salts is not yet understood, it was demonstrated here in an additive-free, low-fat, sterile beef emulsion. Equal or superior inhibition of listeriae and salmonellae can be expected in ready-to-eat (RTE) meats that contain sodium chloride, nitrites, and other antimicrobial additives. Enhanced effect of the inhibitory system is further predicted in most RTE meat products because of their higher fat content (compared with the 5% in the meat emulsion tested in this study) and the partition of the inhibitors in the water fraction of the foods. Moreover, since *Salmonella* Enteritidis is associated with poultry and eggs, the use of the antimicrobials combination can be extended also to RTE foods containing such products. Testing the effect of the

inhibitory system on the two pathogens and the indigenous microorganisms in RTE products is under way.

ACKNOWLEDGMENT

The support of the National Institutes of Health (IMSD no. R25 GM 58905-02) to E. Mbandi is gratefully acknowledged.

REFERENCES

1. Adams, M. R., and C. J. Hall. 1988. Growth inhibition of foodborne pathogens by lactic and acetic acids and their mixtures. Int. J. Food Sci. Technol. 23:287–292.
2. Chen, N., and L. A. Shelef. 1992. Relationship between water activity, salts of lactic acid, and growth of *Listeria monocytogenes* in a meat model system. J. Food Prot. 55:574–578.
3. Code of Federal Regulations. 1991. Sodium diacetate (184.17540). CFR Title 21. Office of Federal Register, U.S. Government Printing Office, Washington, D.C.
4. D'Aoust, J.-Y. 1989. *Salmonella*, p. 327–445. *In* M. P. Doyle (ed.), Foodborne bacterial pathogens. Marcel Dekker, Inc., New York.
5. de Wit, J. C., and F. M. Rombouts. 1990. Antimicrobial activity of sodium lactate. Food Microbiol. 7:113–120.
6. Farber, J. M., and P. I. Peterkin. 1991. *Listeria monocytogenes*, a foodborne pathogen. Microbiol. Rev. 55:476–511.
7. Fleming, D. W., S. L. Cochi, K. L. MacDonald, J. Brondum, P. S. Hayes, B. D. Plikaytis, M. B. Holmes, A. Audurier, C. V. Broome, and A. L. Reingold. 1985. Pasteurized milk as a vehicle of infection in an outbreak of listeriosis. N. Engl. J. Med. 312:404–407.
8. Freese, E., C. W. Sheu, and E. Galliers. 1973. Function of lipophilic acids as antimicrobial food additives. Nature 241:321–325.
9. Houtsma, P. C., M. L. Kant-Muermans, F. M. Rombouts, and M. H. Zwietering. 1996. Model for the combined effects of temperature, pH, and sodium lactate on growth rates of *Listeria innocua* in broth and bologna-type sausages. Appl. Environ. Microbiol. 62:1616–1622.
10. Klontz, K. C., B. Timbo, S. Fein, and A. Levy. 1995. Prevalence of selected food consumption and preparation behaviors associated with increased risk of food-borne disease. J. Food Prot. 58:927–930.
Linnan, M. J., L. Mascol, X. D. Lou, V. Goulet, S. May, C. Salminen, D. W. Hird, M. L. Yonekura, P. Hayes, R. Weaver, A. Audurier, B. D. Plikaytis, and S. L. Fannin. 1988. Epidemic listeriosis associated with Mexican-style cheese. N. Engl. J. Med. 319:823–828.
12. McLauchlin, J., S. M. Hall, S. K. Velani, and R. J. Gilbert. 1991. Human listeriosis and paté: a possible association. Br. Med. J. 303: 773–775.
13. Mishu, B., J. Koehler, L. A. Lee, D. Rodrigue, H. Brenner, P. Blake, and R. V. Tauxe. 1994. Outbreaks of *Salmonella* Enteritidis infections in the United States, 1985–1991. J. Infect. Dis. 169:542–547.
14. Peng, H., and L. A. Shelef. 1999. Automated rapid screening of foods for the presence of Salmonellae. J. Food Prot. 62:1341–1345.
14. Rubin, H. E. 1978. Toxicological model for a two-acid system. Appl. Environ. Microbiol. 36:623–624.
16. Salmond, C. V., R. G. Kroll, and I. R. Booth. 1984. The effect of food preservatives on pH homeostasis in *Escherichia coli*. J. Gen. Microbiol. 130:2843–2850.
17. Schlech, W. F., P. M. Lavigne, A. C. Bortolussi, A. C. Allen, E. V. Haldane, A. J. Wort, A. W. Hightower, S. E. Johnson, S. H. King, and C. V. Broome. 1983. Epidemic listeriosis—evidence of transmission by food. N. Engl. J. Med. 308:203–206.
18. Schlyter, J. H., K. A. Glass, J. Leoffelholz, A. J. Degnan, and J. B. Luchansky. 1993. The effects of diacetate with nitrite, lactate or pediocin on the viability of *Listeria monocytogenes* in turkey slurries. Int. J. Food Microbiol. 19:271–281.
19. Shelef, L. A. 1994. Antimicrobial effects of lactates: a review. J. Food Prot. 57:445–450.
20. Shelef, L. A., and L. Addala. 1994. Inhibition of *Listeria monocytogenes* and other bacteria by sodium diacetate. J. Food Saf. 14:103–115.
21. Shelef, L. A., and Q. Yang. 1991. Growth suppression of *Listeria monocytogenes* by lactates in broth, chicken and beef. J. Food Prot. 54:283–287.
22. SPSS Version 10.0. 2000. SPSS Inc., Chicago, Ill.
23. St. Louis, M. E., D. L. Morse, M. E. Potter, T. M. DeMelfi, J. J. Guzewich, R. V. Tauxe, and P. A. Blake. 1988. The emergence of grade A eggs as a major source of *Salmonella enteritidis* infections. JAMA 259:2103–2107.
24. Todd, E. C. D. 1989. Preliminary estimates of cost of foodborne disease in the United States. J. Food Prot. 52:595–601.
25. U.S. Department of Agriculture, Food Safety Inspection Service. 2000. FSIS to increase permissible levels of food ingredients used as antimicrobials and flavoring agents. http://www.fsis.usda.gov.
26. Weiss, M., T. Roberts, and H. Linstrom. 1993. Food safety issues: modernizing meat inspection. Agriculture outlook AO-197. Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

A FINAL REPORT TO THE

AMERICAN MEAT INSTITUTE FOUNDATION

ANTIMICROBIAL EFFECTS OF SURFACE TREATMENTS AND INGREDIENTS ON CURED RTE MEAT PRODUCTS

From
Jimmy T. Keeton, Ph.D.
Gary R. Acuff, Ph.D.
Maryuri T. Nuñez de Gonzalez, Ph.D. Candidate
Larry J. Ringer, Ph.D.
Lisa M. Lucia

Department of Animal Science
Texas A&M University
College Station, TX 77843-2471
(979) 845-3975
(979) 845-9454 Fax
jkeeton@tamu.edu

December 2002

Key Words: Antimicrobial agents, RTE Meat Products, *Listeria monocytogenes*

EXECUTIVE SUMMARY

Two frankfurters formulations were manufactured under commercial processing conditions to contain no KL (Control) or 3.3% KL. After cooking, chilling and peeling, each batch was divided into inoculated (four strain *Listeria monocytogenes* cocktail) and non-inoculated groups. Sixty minutes after inoculation, each group was treated 30 sec. with one of four different dips: Control (saline solution), acidified calcium sulfate (SWPA), 3.3% potassium lactate (KL) or 3.4% lactic acid (LA). The franks were vacuum packaged, stored under refrigeration (4.5°C) and evaluated at two-week intervals (0, 2, 4, 6, 8, 10, 12). Proximate composition, process yield, vacuum-package purge, a_w, residual nitrite, sodium content, insoluble components (calcium and phosphorus), pH, objective color, sensory evaluation and microbiological shelf-life (APCs) were determined on non-inoculated samples. *L. monocytogenes* counts were determined on inoculated frankfurters. SWPA and LA dips were effective at reducing *L. monocytogenes* counts on the surface of frankfurters. A residual listericidal and listeristatic effect for the SWPA dip was observed when *L. monocytogenes* counts were monitored over storage. The most significant observations were that *L. monocytogenes* numbers were reduced by 5.8 logs on the surface of franks treated with SWPA dip and that after dip treatment *L. monocytogenes* counts remained at the minimum level of detection (1.7 logs) over the 12 week storage period. The addition of KL did not affect fat, protein, ash, process yield, sodium, calcium, phosphorus, vacuum-package purge, pH, a_w, objective color or lactate values; except that percent moisture was slightly lower. Proximate composition of frankfurters was not affected by dip treatments. Vacuum-package purge was slightly higher in samples treated with the SWPA dip and pH of the SWPA franks was 0.83 unit

lower. Only slight changes in surface and internal color were noted for the SWPA dip. A slight increase in calcium content of franks dipped with SWPA was detected. Descriptive attribute sensory panel results indicated minimal effects on the sensory properties of the frankfurters containing KL and dipped in antimicrobial solutions.

INTRODUCTION

Listeria monocytogenes is a foodborne pathogen of significant public health concern due to its virulence in susceptible individuals, and as a consequence has received a presidential mandate for reduction to decrease the incidence of foodborne illness. The annual incidence of listeriosis in the United States has been estimated to be 1850 cases resulting in 425 deaths. Although foodborne listeriosis is rare, the associated mortality rate is as high as 20% among those at risk (FDA 2001). On May 5, 2000, President Clinton issued a directive to the Department of Health and Human Services (HHS) in cooperation with United States Department of Agriculture-Food Safety Inspection Service (USDA-FSIS) to conduct a risk assessment of *Listeria monocytogenes*. The Administration also proposed a goal of cutting the number of *Listeria* caused illness in half by year 2010. In response to the President's directive, the National Advisory Committee on Meat and Poultry Inspection (NACMPI) produced an issue paper recommending a revised action plan for control of *L. monocytogenes* to prevent food-borne listeriosis in meat and poultry products.

L. monocytogenes is a facultative, intracellular gram-positive, nonsporeforming and psychrotrophic bacterium that causes the disease called listeriosis. Immunocompromised individuals, infants, pregnant women and elderly persons are the most at risk. In humans, the primary manifestations of listeriosis are meningitis, abortion and prenatal septicemia (FDA 2001). The infectious dose of *L. monocytogenes* is unknown. It is an ubiquitous organism able to survive and multiply at refrigeration temperatures in the presence or absence of oxygen, and can tolerate a range of pHs and concentrations of up to 12-13% salt. Moreover, some strains may grow at a water activity

(a_w) as low as 0.9 and at a pH value as low as 4.4 (Walker and others 1990; Farber and Peterkin 1991, Miller 1992).

Ready-to-eat (RTE) products, such as hot dogs, lunchmeats, smoked fish, and certain types of soft cheeses, are among the foods most commonly associated with food-related listeriosis. Thus, a "zero tolerance" for *L. monocytogenes* in RTE foods has been specified by FDA based on the characteristics of this microorganism and the reported cases of listeriosis (Ryser and Marth 1999). Contamination of RTE food products with *L. monocytogenes* primarily occurs post-processing and prior to consumption of these products. Even though cured RTE meat products contain sodium chloride and nitrite salts in their formulations that possess antimicrobial properties, they are not able to inhibit the growth of *L. monocytogenes* under refrigerated storage conditions (Mbandi and Shelef 2002).

The safety of RTE meat products, which may be consumed without additional heat treatment, can be enhanced by adding substances to serve as microbiological hurdles and suppress the growth of *L. monocytogenes*. Such hurdles include pH lowering substances such as lactic acid and other organic compounds. Antilisterial effects of organic acids, their salts or combinations have been examined in several types of meat products. Shelef and Yang (1991) showed growth suppression of *L. monocytogenes* by lactate (4%) in sterile broth, and on chicken and beef. Chen and Shelef (1992) studied the relationship between water activity (a_w), salts of lactic acid, and growth of *L. monocytogenes* strain Scott A in a meat model system. They found that lactate concentrations less than 4% were not listeristatic, but combinations of 2 or 3% lactate with 2% NaCl inhibited the growth of *L. monocytogenes*. Sodium lactate (3 or 4%) was found to be effective against the growth

of *L. monocytogenes* in cooked beef stored at 10°C when compared to 0 or 2% levels (Miller and Acuff 1994). Artificial contamination of frankfurters with *L. monocytogenes* followed by a 2 min dip in 1% lactic, acetic, tartaric, or citric acids resulted in a 1-2 log kill of the bacteria (Palumbo and Williams 1994). However, surviving bacteria recovered and began to grow during refrigerated storage. By dipping in 5% acetic or lactic acid, *L. monocytogenes* was not only killed, but also prevented from growing during 90 days of refrigerated storage. Mbandi and Shelef (2001) found enhanced inhibition of *L. monocytogenes* Scott A in sterile comminuted beef at 5 and 10°C using a combination of sodium lactate (2.5%) and sodium diacetate (0.2%). They also, evaluated the inhibitory effect of these salts alone and in combination in RTE meat inoculated with a single strain or a cocktail of six strains of *Listeria*. These salts delayed growth of listeriae at 5°C and the effect of their combination was listericidal for *L. monocytogenes* Scott A and listeristatic for the six-strain mixture (Mbandi and Shelef 2002).

Sodium and/or potassium lactate (Purasal®, PURAC America, Inc., Lincolnshire, IL) at levels of 2 to 4% have been shown to act as bacteriostatic agents against pathogenic bacteria such as *L. monocytogenes*, *E. coli* O157:H7 and *Salmonella* when incorporated into a variety of RTE meat products (Houstsma et al 1996; Murano and Rust 1995; Nerbrink and others 1999; Shelef 1994; Stekelenburg and Kant-Muermans 2001). Sodium or potassium lactate is available commercially as a neutral aqueous solution (60%), and approved for use as a flavoring agent at levels of up to 4.8% in emulsified products (9 CFR, 424.21, 2002) such as frankfurters, bologna and wieners. Both may be used at concentrations up to 4.8% (or a concentration of 2.9% of a 100% solution) as a secondary ingredient to inhibit the growth of pathogenic bacteria in refrigerated, RTE,

hermetically packaged, cooked, uncured and cured meats. Therefore, the incorporation or a surface application of lactate could potentially afford protection against pathogen outgrowth in or on RTE products and provide additional protection to consumers.

$Safe_2O^{TM}$ (Mionix Corporation, Naperville, IL), an organic acid, calcium sulfate combination, has been shown in preliminary tests to dramatically reduce the total numbers of aerobic bacteria on the surface of frankfurters. All $Safe_2O^{TM}$ ingredients are affirmed as GRAS (generally recognized as safe) under the FDA Code and their bacteriostatic effect is thought to be due to hydronium ions that inactivate bacterial membrane proton pumps. For these reasons, $Safe_2O^{TM}$ may have tremendous potential as an effective bacteriostatic preservative against pathogenic microorganisms such as *L. monocytogenes*. Thus, this preservative, when incorporated into or applied to the surface of RTE products, may afford a degree of protection against pathogens that has not been demonstrated by other products. The objective of this study was to test the effectiveness of preservative compounds applied to the surface of frankfurters immediately prior to packaging in concert with a selected preservative (potassium lactate) added as an ingredient. The outcome of this project would play an important role in reducing the risk of pathogen contamination in RTE products and provide a means of achieving the President's Healthy People Goal by 2005 rather than by 2010.

OBJECTIVES

1. To determine the preservative properties of potassium lactate (KL) as an ingredient for preserving quality and extending the shelf-life of vacuum packaged, cured, ready-to-eat (RTE) frankfurters.

2. To evaluate the effectiveness of a surface application of either lactic acid (LA), $Safe_2O^{TM}$ + propionic acid (SWPA) or potassium lactate (KL) on frankfurters in combination with KL as an ingredient for suppressing the outgrowth of *Listeria monocytogenes*.

3. To evaluate the sensory, physical and chemical properties of vacuum-packaged frankfurters containing KL with a surface application of LA, SWPA or KL.

MATERIALS AND METHODS

Potassium lactate (3.3%, 60% concentration) solution was incorporated into 22.7 kg (50 lbs) of a standardized frankfurter formulation and compared to a control formulation without the ingredient. Each batch was divided into an inoculated (*L. monocytogenes*) and non-inoculated group. Both groups were dipped into a saline solution (control), dilute $Safe_2O^{TM}$ with propionic acid (SWPA, 1:2 water, pH = 1.64), 3.3% potassium lactate (KL, pH = 6.32) or 3.4% lactic acid (LA, pH = 2.16) (88% concentration) for 30 sec and then drained for 30 sec followed by vacuum packaging and storage under refrigeration (4.5°C). Evaluations were performed at two-week intervals (0, 2, 4, 6, 8, 10, 12) for 12 weeks. The following analytical procedures were performed on the treatments of non-inoculated samples: vacuum purge release, water activity, residual nitrite, salt content, total lactate, insoluble components (calcium and phosphate), pH, objective color, sensory evaluation and microbiological shelf-life (Aerobic Plate Counts). Some analyses were only performed one time per replication such as process yield, proximate analysis (percentage of moisture, fat, protein and ash), salt content and insoluble components (calcium and phosphorus). Residual nitrite was determined three times per replicate after 0, 8 and 12 weeks of storage, respectively. *L. monocytogenes* counts were determined on inoculated frankfurters at each storage period. A total of two replications were performed for this study.

Frankfurter Preparation

Frankfurters were prepared in a state inspected (Texas Department of Health), commercial-scale pilot plant located in the Rosenthal Meat Science and Technology Center at Texas A&M University. Fresh and/or frozen lean beef trimmings and pork fat trimmings (-2° to 3°C) were selected, coarse ground through a 1.27 cm (1/2") plate,

reground through a 0.48 cm (3/16") plate, analyzed for fat content and formulated to achieve a 20% fat endpoint. A base formulation of raw materials, dry ingredients and water are shown in Table 1 and represent calculations to yield a finished product with the following specifications: 70 to 75% meat block, ~28% ether extractable fat based on the meat block or 20% fat based on the finished batch weight, 56 to 58% moisture, pH 6.0 to 6.3, 2.25 to 2.5% salt (sodium chloride), 0.35 to 0.5% sodium tripolyphosphate, and <156 mg/kg (ppm) of sodium nitrite (calculated on the meat component). An automated, staged standard processing cycle for frankfurters was selected to achieve an endpoint temperature of 71.1°C (160°F) in a commercial processing oven.

Table 1. Frankfurter formulation ingredients calculated on a raw batch weigh basis

Ingredients	Formulation Treatments	
	Control (%)	Potassium Lactate (%)
Meat Trimmings		
Lean beef trim (85/15)	74.1	71.7
Pork fat trim (60/40)	38.4	37.2
Non-meat Ingredients	35.7	34.6
Salt*	25.9	28.3
Potassium Lactate (as specified)	1.66	1.61
Corn Syrup Solids (DE 42)**	-	3.3
HMP or HVP	1.48	1.43
Hydrolyzed Beef Stock	0.74	0.72
Sodium Tripolyphosphate	0.37	0.36
Spice/Seasoning	0.33	0.32
Sodium Erythorbate	0.37	0.36
Sodium Nitrite (cure blend)***	0.037	0.036
Added Water	0.185	0.179
10% Added Water (Cook Shrink)	13.3	12.9
Total (Batter)	7.4	7.2
	100.0	100.0

*For each percent sodium lactate, sodium chloride was reduced 0.1%, for example: total NaCl was reduced to 2.05% with the addition of 2.0% K Lactate (100% basis) or 3.3% K Lactate (60% basis).
**DE = Dextrose Equivalent
***Cure blend contains 6.25% sodium nitrite bonded to 93.75% salt. Pure nitrite, if used, would be added at 0.011% while the salt would be increased to 1.84%.

Analytical Techniques

Process Yield

The percentage of process yield was determined, by dividing the cooked product weight by the raw uncooked weight product and multiplying by 100, using the following equation:

$$\text{Percent Process Yield} = \frac{\text{Finished Product Weight}}{\text{Raw Product Weight}} \times 100$$

Vacuum Purge Release

The percentage of vacuum purge released during storage was determined on vacuum packaged product (four franks/package from each treatment) at 14-day intervals, over a 12 week refrigerated (4°C) storage period. Each package was weighed to obtain a total package weight and opened. The contents (franks and package) were hand dried with paper towels and reweighed. Finally, the percent of vacuum purge release was determined using the following equation:

$$\text{Percent Vacuum Package Purge} = \frac{\text{Purge Weight}}{\text{Product Weight + Purge Weight}} \times 100$$

Proximate Analysis

Percentages of moisture, fat, protein and ash were determined on the cooked frankfurters according to AOAC (2000) procedures. Eight franks per treatment were homogenized in a food processor (Cuisinart Inc., Model DLC-8M, Norwich, CT) before sampling. Proximate analysis was performed on frankfurters assigned to the week 0 and stored (-20°C) under frozen conditions until the day of analysis. Moisture content (%)

was determined by microwave drying using the CEM SMART TRAC™ System 5 moisture analyzer (CEM Corporation, Matthews, NC). Fat content (%) was determined by methylene chloride extraction of the dried samples (CEM fat analyzer, Model FAS-9001, CEM Corporation, Matthews, NC). Crude protein percentage was determined by the Dumas sample combustion method to release gaseous N_2 in a Leco FP-528 Protein Analyzer (St. Joseph, MO). The procedure was standardized using ethylenediamine tetraacetic acid (EDTA) (Leco Lot # 1030, %N = 9.56 ± 0.03) and Orchard leaves (Leco Lot # 1005, %N = 2.55 ± 0.05). Percent crude protein was calculated as 6.25 times the percent nitrogen. Ash content was determined by the muffle furnace method. Analysis of the samples was performed in duplicate.

Water Activity

Water activity (a_w) values were determined using an Aqua Lab™ (model series 3, Decagon Devices Inc., Washington, USA). Eight franks per treatment were taken at each test week (0, 2, 4, 6, 8, 10, 12) and homogenized in a food processor (Cuisinart Inc., Model DLC-8M, Norwich, CT) before sampling. Approximately, 8 grams of homogenized sample were spread evenly on the bottom of an Aqua Lab sample cup, positioned inside the vapor chamber, and a reading was obtained after 3-5 min of equilibration. The a_w of each treatment was performed by triplicate over the 12 week storage period.

Residual Nitrite

Residual nitrite values of each treatment and at storage weeks 0, 8 and 12 were determined by a colorimetric method according to AOAC (2000) procedures. Residual

nitrite determinations were performed in duplicate and the results were reported as ppm (mg/kg).

Salt Content

Salt content was determined by potentiometry using an ion specific electrode (Model 86-11 combination electrode for sodium, Orion Research Inc., Beverly, MA) calibrated with dilutions of a 1000 ppm sodium standard (No 841108, Orion Research Inc., Beverly, MA), and a digital pH meter (Model 720A, Orion Research Inc., Beverly, MA). Determinations of salt content were performed on frankfurters assigned to week 0 and stored (-20°C) under frozen conditions until the day of analysis. Ten grams of thawed sample were homogenized for 30 sec. with 240 ml of distilled water (1:25 dilution) using a Waring® blender (Model 31BL92, Waring Products Division, Dynamics Corp. of America, New Hartford, CT). Finally, a 50 ml aliquot of the slurry was combined with 5 ml of sodium ionic strength adjustor (ISA, No 841111, Orion Research Inc., Beverly, MA), with continuous stirring, and the sodium electrode inserted into the slurry for a reading. A standard curve was developed with anchor points at 100 (minimum) and 1000 ppm (maximum) sodium Na^+ standard (1000 ppm, No 841108, Orion Research Inc., Beverly, MA). Measurements were taken on duplicate slurry homogenates and the results were reported as percentage of sodium ion.

Total Lactate

Total lactate at each designated test week was determined by an enzymatic and colorimetric method using a Sigma Diagnostics Kit (Procedure No 500 Sigma Diagnostics, Inc., St. Louis, MO). Seven grams of sample were homogenized at three intermittent times for 30 sec. each with 35 ml of distilled water (1:5 dilution) using a

Waring® blender (Model 31BL92, Waring Products Division, Dynamics Corp. of America, New Hartford, CT). The slurry was placed in a plastic centrifuge tube and centrifuged at 30,000 x g for 15 min using a Beckman Avanti® J-25 centrifuge (Beckman Instruments, Inc., Palo Alto, CA). One milliliter aliquots were placed in 1.7 ml micro-centrifuge tubes (No 20170-610, VWR Scientific Products, West Chester, PA) and enzymatic and colorimetric procedures performed in duplicate. Absorbance readings were taken at 540 nm using a Cary 300 Bio UV-visible double-beam spectrophotometer (Varian, Optical Spectroscopy Instruments, Victoria, Australia). Results were reported as mg of lactate per gram of tissue.

Insoluble Components

Calcium content was determined by potentiometry using an ion specific electrode (Model 93-20 electrode for calcium, Orion Research Inc., Beverly, MA) attached to a pH meter (Model 720A, Orion Research Inc., Beverly, MA) and calibrated with 0.1 M Ca^{2+} standard (No 922006, Orion Research Inc., Beverly, MA). Thirty grams of homogenized sample was blended with 270 ml of double distilled water (1:10 dilution) for 30 sec in a Waring® Blendor (Model 31BL92, Waring® Products Division, Dynamics Corp. of America, New Hartford, CT). The slurry was filtered through cheesecloth mini-wipes (VWR Scientific Products, West Chester, PA) to remove particulates. Finally, 50 ml of slurry were combined with 1 ml of calcium ionic strength adjustor (ISA, No 932011, Orion Research Inc., Beverly, MA), stirred thoroughly, and the calcium and reference electrodes inserted into the slurry for a reading. A standard curve was developed with anchor points at 1 (minimum) and 10 ppm (maximum) of 0.1 M Ca^{2+} standard (No

922006, Orion Research Inc., Beverly, MA). Duplicate measurements were taken on slurried homogenates and the results reported as mg of calcium per 100 g of tissue.

Phosphorus content was determined in duplicate by the Inductively Coupled Plasma Method (Atomic Emission Spectrophotometry) at ABC Labs, Gainesville, FL. Duplicate measurements were taken on slurried homogenates and results reported as mg of phosphorus per 100 g of edible portion.

pH Determination

pH measurements of franks from each treatment were determined by the slurry method adapted for meat products utilizing an Orion™ (model 720A, Orion Research Inc., Beverly, MA) pH meter standardized with pH 4 and 7 buffers and fitted with a combination electrode. Thirty grams of homogenized sample was blended with 90 ml of double distilled water for 2 min in a Waring® Blendor (Model 31BL92, Waring® Products Division, Dynamics Corp. of America, New Hartford, CT) and the pH electrode inserted into the stirred slurry for a reading.

Objective Color

L*, a*, b* color space values of the frankfurter treatments were obtained by reflectance using a Minolta Colorimeter (model CR-200, Minolta Co., Ramsey, NJ), calibrated to a white tile standard surface (L* = 97.55, a* = -0.02, b* = 1.56) at channel 00. Two frankfurters per treatment at each test week were sliced in half longitudinally, the open face of the frankfurters covered with clean Saran® wrap, and random readings taken from the surface and inside of the franks at three locations. The results were expressed as L* (lightness), a* (redness) and b* (yellowness) values.

Sensory Evaluation

Frankfurter samples from each treatment (at each designated test week) were evaluated by a trained descriptive attribute sensory panel (4-7 members) at the Texas A&M Sensory Testing Facility. The panel was selected and trained according to procedures of Cross and others (1978), Meilgaard and others (1991) and AMSA (1995) guidelines. Training prior to testing was conducted by presenting reference samples to the panel to characterize the basic attributes of franks with the different treatments used in the study. The samples were evaluated for aromatics (overall meat flavor, fatty, smoke, spice complex, cardboard, painty, fishy, livery, caramelized, soured, soapy, musty and vinegar), feeling factors (astringent and metallic), basic tastes (salt, sour, bitter and sweet), aftertastes (fat mouthfeel, sour, spice, bitter, metallic, sweet, salty, vinegar and smoke) and texture (springiness, juiciness, hardness and cohesiveness of mass) using a 16-point Spectrum Universal intensity scale (Meilgaard and others 1991) where 0 = absence of an attribute and 15 = extremely intense.

Samples of refrigerated franks from each treatment were evaluated at two weeks intervals (0, 2, 4, 6, 8, 10, 12) for twelve weeks. On each testing day, eight samples were evaluated per day during one session with four samples being served five minutes apart. The order of the treatments was randomized and a warm-up was presented to judges prior to sample evaluation to ensure that they had identified the treatment attribute to be tasted. The stimuli used for warm-up were franks from a control formulation with a dip containing saline solution (control). Samples of refrigerated precooked franks were steeped in boiling water for seven minutes. Three, warm cross-cut pieces (1.5 cm) from each treatment, randomly codified with three-digit codes, were served to each panelist.

Judges were seated in separated booths to avoid communication during the evaluation, and the samples were presented to panelists through stainless steel hoods adjacent to the preparation area. Testing was conducted under red filtered, incandescent lighting to mask color. Distilled water, unsalted crackers and ricotta cheese were given to judges to cleanse their mouths.

Subjective color of the surface and interior of longitudinally sliced franks were evaluated by the sensory panel. The uncooked franks were sliced in half longitudinally and presented to panelists under white incandescent lighting (Sylvania light bulbs incandescent, 150 W and 120 V., Sylvania Electronics, Danvers, MA) to simulate store conditions. Subjective color was determined using a 7-point scale for surface (1 = very dark reddish-brown; 7 = very pale pink) and interior views (7 = no cured color-gray; 1 = extremely pink color) of the samples in accordance with AMSA (1995) procedures.

Microbiological Analysis

Frankfurters (containing either no KL or 3.3% KL) were divided into inoculated and non-inoculated groups after the cooking, chilling and peeling operations. Designated samples were surface inoculated with a *Listeria monocytogenes* mixture (cocktail) and then treated with four different dip solutions. For microbiological shelf-life determinations of non-inoculated samples, Aerobic Plate Counts (APCs) were performed on the treatments (franks containing either no KL or 3.3% KL and treated with four different dip solutions).

Bacterial Cultures and Inoculum Preparation

Four strains of *L. monocytogenes* (ATCC 15313, 51414, 43256 and 49594) were used in this study. Cultures were grown in tryptic soy broth (TSB, Difco Laboratories, Detroit, MI) overnight at 35°C and then pooled immediately prior to use as an inoculum.

Twenty-one franks per treatment were transferred into sterile tubs and surface inoculated with 0.1ml of the *L. monocytogenes* mixture to give a final concentration of approximately 10^8 CFU/ml. One hour post inoculation, the inoculated samples were submerged in a dip containing saline solution (Control), SWPA, KL or LA for 30 sec and then drained for 30 sec. Samples then were placed in Cryovac® 10.16 cm x 30.48 cm (4 in x 12 in) bags (Type B540T, Cryovac® North America, Duncan, SC), vacuum packaged (KOCH Inc., Model X180, Germany), stored at 4.5°C (40°F) and evaluated at two-week intervals (0, 2, 4, 6, 8, 10 and 12) for twelve weeks.

Listeria monocytogenes

At each designated test interval, inoculated samples were analyzed in duplicate for recovery and enumeration of *L. monocytogenes*. One frank was aseptically removed from the package, transferred into a stomacher bag with 99 ml of 0.1% peptone water (Difco Laboratories, Detroit, MI) and massaged by hand for 1 min. Decimal dilutions were prepared with 9 ml of 0.1% peptone water and surface plated on to Modified Oxford Medium (MOX) (Difco Laboratories, Detroit, MI). Thus, an aliquot (0.1ml) was placed on the agar plate and then uniformly spread on the agar surface with a sterile bent glass rod. Typical colonies were counted after incubation of the plates at 37°C for 48 h and then recorded as $\log_{10}$ CFU/Frank.

Aerobic Plate Count

To evaluate microbiological shelf-life, Aerobic Plate Counts (APCs) were performed on the treatments for non-inoculated samples at each designated test week. One frank was aseptically removed from the packaging material, transferred into a stomacher bag with 99 ml of 0.1% peptone water and the mixture massaged by hand for 1 min. Decimal dilutions were prepared and 1 ml of the appropriate dilution was placed onto Petrifilm™ Aerobic Count Plates (3 M, St. Paul, MN). Colonies were counted after incubation of plates at 25°C for 48 h, and then recorded as $\log_{10}$ CFU/Frank.

Statistical Analysis

Data were analyzed as a split-plot design using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 1995). Analysis of variance was used to determine statistical differences among the main effects and their interactions with a significance level of $P < 0.05$. Least square means were used to identify significant treatment effects. For microbiological analysis, count data were transformed into base 10 logarithms. *L. monocytogenes* Log_{10} reduction values were calculated by substracting the Log_{10} count of positive control and the Log_{10} count of each treatment on inoculated frank surface. The experiment was replicated two times.

RESULTS AND DISCUSSION

Physical and Chemical Evaluations of frankfurters

Percentages of moisture, fat, protein and ash are shown in Table 2. No differences ($P > 0.05$) were observed in these variables between the control and the potassium lactate (KL) treatment, except that percent moisture was slightly lower in franks with KL. In general, the addition of KL did not change the chemical composition of the frankfurters. Likewise, no differences ($P > 0.05$) were observed in the percent moisture, fat, protein and ash of franks treated with different dips.

Results for percent process yield, percent sodium, calcium and phosphorus contents are presented in Table 3. Process yield and the sodium, calcium and phosphorus content of the franks were not affected ($P > 0.05$) by the addition of KL. However, $Safe_2O$™ (SWPA) increased ($P< 0.05$) calcium content by 2.46 mg/100g over the control. This was likely caused by the SWPA material which contains a calcium sulfate complex. There was also an ingredient treatment by dip interaction for calcium (Table 4) that showed calcium levels to increase by 2.88 and 2.04 mg/100 g in frankfurters containing either no KL or 3.3% KL, respectively, and dipped with SWPA. The increase in calcium content of the frankfurters could enhance their nutritional value through calcium enrichment.

As shown in Table 5, the vacuum-package purge, pH, objective color values (surface and internal) and lactate and residual nitrite content were not affected ($P > 0.05$) by the addition of KL. However, the water activity (a_w) was slightly lower ($P< 0.05$) in franks with KL. Vacuum-package purge (Table 5) was slightly higher (0.66%) in franks treated with SWPA dip when compared to ($P< 0.05$) the control or other dip treatments. Franks treated

with KL dip had the lowest percent vacuum-package purge or about 0.3% less than the control. No differences ($P > 0.05$) were observed between the control and LA dip.

The pH decreased ($P < 0.05$) by 0.83 unit (Table 5) due to application of the SWPA dip while the LA treatment reduced the pH 0.12 unit less than the control. Moreover, no differences in pH were found in franks treated with KL when compared to control. The pH lowering effects of SWPA, as well as LA, were due to their naturally low acidity (pH = 1.64 and 2.16, respectively). Reductions in vacuum-package purge were also likely due to the increased acidity of the dips.

Among the dip treatments, only the franks treated with SWPA were slightly lower ($P< 0.05$) in a_w (Table 5).

Results for objective color (surface and internal) values are presented in Table 5. The addition of KL did not change the surface nor internal (L*, a*, b*) color attributes of the franks. However, surface L* (lightness) values of SWPA and LA dips were slightly lower, ($P< 0.05$) indicating a darker frank, when compared to the control. The KL dip had no effect on surface L* value. Surface redness (a*) increased slightly with the SWPA dip, but no differences ($P > 0.05$) were observed among the control, KL and LA treatments. Surface b* (yellowness) values were not different ($P > 0.05$) among dip treatments.

Internal a* values or redness (Table 5) were slightly lower ($P< 0.05$) in franks treated with KL and LA, but not different for the SWPA treatment. Franks treated with SWPA had lower b* values (less yellow) than the control, but no differences ($P > 0.05$) in internal L* values were observed among the other dip treatments. It can be concluded that the SWPA treatment made the surface of the franks slightly darker (lower L* values), increased surface redness (higher a* values) and decreased internal yellowness (lower b* values). Although

these differences were statistically significant, the color space value differences were of such small magnitude that they would not likely be detectable by consumers.

Lactate levels (Table 5) in the frankfurters were not affected ($P > 0.05$) by dip treatments in this study.

Residual nitrite of the SWPA dip was not affected ($P > 0.05$) by the addition of KL (Table 5). However, residual nitrite was lower ($P < 0.05$) by 1.16 ppm when compared to the control. No differences in residual nitrite contents were found in franks treated with KL or LA.

Storage had a small effect on pH, a_w, objective color (surface and internal), lactate concentration and residual nitrite values (Table 6). However, there was no change in percent vacuum-package purge due to storage under refrigerated conditions for 12 weeks.

The pH increased ($P < 0.05$) slightly during the 6th and 8th weeks of storage but returned to initial levels on weeks 10 and 12. Ingredient treatment (KL) by storage week and dip treatment by storage week interactions for pH are shown in Table 7 and 8. In general, the control pH decreased slightly with storage (Table 7) after week 10. Also, the inclusion of KL in the frankfurters increased pH slightly after week 10. According to dip by week interaction (Table 8), the application of the SWPA and LA dips decreased ($P < 0.05$) frankfurter pH values when compared to the other dip treatments.

Water activity (a_w) increased slightly as storage progressed (Table 6) with the lowest a_w values observed at week 0. Moreover, there were ingredient by storage week (Table 9) and ingredient by dip by storage week (data not shown) interactions for a_w. Inclusion of KL as an ingredient (Table 9) kept the a_w lower throughout 12 weeks of simulated retail storage at 4.5°C, thus tending to provide some inhibition to pathogen growth. In general, a_w

gradually increased ($P< 0.05$) in frankfurters with KL over refrigerated storage but overall a_w levels of the KL treatment were lower than the control.

There were no clear patterns observed for changes in frankfurter surface and internal color values (Table 6) over a 12-week refrigerated (4°C) storage period. Overall, storage at 4°C for 12 weeks did not affect surface and internal lightness and redness in frankfurters.

In general, lactate content (Table 6) varied ($P< 0.05$) during the 12-week storage period. The highest values for lactate were observed on weeks 4, 8 and 12. Residual nitrite values decreased ($P< 0.05$) during the 12-week storage period and Tables 10 and 11 show the ingredient treatment by storage week and dip by storage week interactions. Frankfurters made with KL had slightly lower ($P< 0.05$) residual nitrite as compared to the control at week 0. In Table 11, levels of residual nitrite for the SWPA dip were the lowest among all treatments at week 0. Lower levels of residual nitrite were likely caused by the lower pH of SWPA. Studies have shown that less than 10% of the sodium nitrite used in the curing process remains in the finished product (Cassens 1997). Also, it has been reported that the levels of residual nitrite decrease in cured products with increased storage time (Woolford and Cassens 1977; Cassens and others 1974; Kemp and others 1975). The use of nitrite in cured meat products has been challenged as a potential health risk to human beings and as a necessary component for nitrosamine formation. Thus, cured meat products with lower levels of residual nitrite might be advantageous.

Sensory Evaluation

Descriptive attribute sensory panel evaluations of frankfurters containing KL (Table 12) indicated that the inclusion of KL had some effect ($P< 0.05$) on aromatics, feeling factors, basic taste and aftertaste attributes. The addition of KL slightly increased fatty,

astringent, bitter and bitter aftertaste attributes while cardboard, painty and fishy flavor/aromatics, descriptors associated with warmed-over-flavor (WOF), were not affected by the addition of KL. No differences ($P > 0.05$) in springiness, juiciness, hardness and cohesiveness of mass were found in frankfurters with KL.

Antimicrobial dips applied on surface of frankfurters (Table 13) appeared to have little effect on the sensory properties of the frankfurters. Sensory panelists found a slight decreased ($P< 0.05$) in overall meat flavor (most dominant flavor) and sweet taste in franks treated with SWPA as compared to the other dip treatments. Moreover, some descriptive attributes such as caramelized and vinegar flavors, astringent feeling factor, sour, bitter, and sweet tastes, sour aftertaste and hardness were increased slightly by SWPA dip. Off-flavor notes were not affected ($P< 0.05$) by antimicrobial dips. Overall, SWPA dip only had a slight effect on some sensory properties of the frankfurters. These differences were at the minimal level of detection and would not likely be perceived by consumers.

As shown in Table 14, storage caused only minor changes ($P< 0.05$) in sensory flavors, feeling factors, tastes, aftertaste and textural attributes. The descriptive attributes affected across storage periods were: overall meat flavor, fatty and caramelized flavors; astringent and metallic feeling factors; sour and sweet tastes; sour and vinegar aftertastes; and springiness, juiciness, hardness and cohesiveness of mass. Overall meat flavor scores of franks increased ($P< 0.05$) slightly after 8 weeks of refrigerated storage, but were not different after 12 weeks from those at 0 week. Fatty flavor scores increased ($P< 0.05$) slightly after 2 weeks, but then declined slightly throughout the 12-week storage period.

Off-flavor was not affected ($P< 0.05$) by refrigerated storage period. Caramelized flavor scores were highest on week 6 and 10. Sensory panelists detected a higher astringent

feeling for franks after 6 weeks and a lower metallic feeling on week 8. Sour taste tended to increase with storage and sweet taste was lower on week 8.

All aftertastes were detected at low levels but only sour and vinegar aftertastes were affected ($P< 0.05$) over storage. Sour aftertaste tended to increase with storage and vinegar increased slightly by week 12.

Springiness scores were higher on weeks 4, 8 and 10, and juiciness score was lower on week 4. Hardness decreased ($P< 0.05$) after 2 weeks, then increased slightly after 4 weeks, but at the end of the storage period was not different to week 0. Cohesiveness scores were lower on weeks 6, 8 and 10. Overall, storage for 12 weeks at 4.5°C had minimal effect on descriptive attributes of the frankfurters.

Comparative results of ingredient and dip treatments for subjective panel color and objective color determinations on the surface and the interior of franks are presented in Table 15. The addition of KL did not affect ($P< 0.05$) sensory or objective color of frankfurters, except that surface a* values or redness were slightly lower in franks treated with KL. Franks treated with SWPA had slightly lower ($P< 0.05$) surface color scores as compared to the other antimicrobial dips. No differences in surface color scores were found in franks treated with SWPA and LA. SWPA dip made the surface of the franks slightly darker, increased surface redness and decreased internal yellowness. Overall, the SWPA dip appeared to enhance surface redness of franks. However, surface lightness and internal yellowness were diminished slightly.

Sensory and objective color data over storage time (Table 16) indicated that surface color did not change and that internal color scores varied slightly with time. Surface and

internal color L* values were higher, and a* and b* values were lower on week 8. However, there were no clear internal color value patterns observed for franks over storage time.

Microbial Evaluation of Frankfurters

Addition of KL did not affect (P > 0.05) APC and *L. monocytogenes* counts (Table 17) of the frankfurters. SWPA and LA dips tended to decrease (P< 0.05) APC counts slightly, but no statistical differences (P > 0.05) were observed in franks for either treatment. Franks treated with KL dip tended to have higher APC counts among the dip treatments, but KL was not different from the control.

Compared with the control (Table 17), *L. monocytogenes* on inoculated franks treated with SWPA and LA dips diminished significantly, and especially with the SWPA treatment. *L. monocytogenes* numbers were reduced (P< 0.05) by 5.8 and 3.2 logs (Table 17), respectively, on frankfurters treated with SWPA and LA. These results demonstrate the antimicrobial effectiveness of these two treatments for reducing *L. monocytogenes* on the surface of frankfurters, and therefore could afford considerable protection to RTE products against this microorganism. The mode action of organic acids for inhibiting microbial growth appears to be associated to proton donation, maintenance of acid-base equilibrium and production energy from the cells (Davidson and Branen 1993).

Microbial evaluations of frankfurters during a 12-week refrigerated storage period are presented in the Table 18. APC counts ($\log_{10}$ CFU/Frank) of the pooled non-inoculated samples increased approximately 0.7 to 1.6 logs over 12 weeks. Total log numbers of *L. monocytogenes* increased (P< 0.05) on inoculated samples over a 12 week refrigerated (4°C) storage period, but because the treatment by storage weeks interaction was significant, the true effects are better presented in Table 19. *L. monocytogenes* counts during storage

increased ($P < 0.05$) on the frankfurter surface of all dip treatments except SWPA. Log counts for SWPA remained at the minimum detection level of approximately 1.7 logs over 12 weeks at 4.5°C. These results are indicative of SWPA's listericidal and listeristatic effect since the initial inoculation level, prior to dipping, was 6.6 logs on the control. Thus, SWPA is an effective listericidal and listeristatic surface treatment for frankfurters stored under refrigerated conditions over a 12-week period.

SUMMARY AND CONCLUSIONS

The most significant observation in this study was that SWPA and LA dips were effective for reducing *L. monocytogenes* counts on the surface of frankfurters. *L. monocytogenes* counts on the SWPA treated franks remained at 1.7 logs, the minimum level of detection, after dipping and throughout 12 weeks of storage at 4.5°C. *L. monocytogenes* increased on all other dip treatments during storage, except SWPA. Thus, these results demonstrate a residual protective effect for the SWPA application over the storage period studied.

Potassium lactate used as ingredient in frankfurters did not affect chemical composition (except percent moisture), process yield, sodium, phosphorus, vacuum-package purge, pH, a_w, lactate or objective color values.

Proximate composition of frankfurters was not affected by dip treatments, but the SWPA dip slightly increased vacuum-package purge and decreased pH by 0.83 unit. Surface and internal color values were slightly affected by the SWPA dip, but these differences were of such a small magnitude that they may not be detected by consumers.

Trained panel sensory evaluations indicated that the inclusion of KL in the frank formulation slightly increased fatty, astringent, bitter and bitter aftertaste attributes, but that antimicrobial dips applied to the surface of the franks appeared to have little effect on sensory properties. Overall, sensory attributes were minimally affected by addition of KL to the frankfurters or by the antimicrobial dip treatments.

REFERENCES

AMSA. 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat, Am Meat Sci. Assn., National Livestock and Meat Board, Chicago, IL.

AOAC. 2000. Official Methods of Analysis. AOAC International, 17th Ed., Gaithersburg, MD.

Cassens R G, Sebranek J G, Kubberod G and Woolford G. 1974. Where does the nitrite go? Food Product Development 8(10):50.

Cassens R G. 1997. Residual nitrite in cured meats. Food Technol. 51:53-55.

Chen N and Shelef L A. 1992. Relationship between water activity, salts of lactic acid, and growth of Listeria monocytogenes in a meat model system. J. Food Prot. 55:574-578.

Clinton W J. "Reducing the risk of *Listeria monocytogenes*", A Memorandum, the White House, May 5, 2000. Washington, DC. http://www.fsis.usda.gov/oppde/nacmpi/may2000/listeria%5Fpaper.html

Cross H R, Moen R and Stanfield M S. 1978. Training and testing of judges for sensory analysis of meat quality. Food Technology 32:48-54.

Davidson P M and Branen A L (Eds.). 1993. Antimicrobials in Foods. Marcel Dekker, Inc., New York.

Farber J M and Peterkin P I. 1991. *Listeria monocytogenes* a food borne pathogen. Microbiol. Rev. 55: 476-511.

FDA. 2001. Background provided by FDA to IFT. J Food Sci (Suppl.) 66(7): S-1059-1060.

Gellin B G and Broome C V. 1989. Listeriosis. J. Am Med Assoc. 269(9):1313-1320.

Houstma P C, De Wit J C and Rombouts F M. 1996. Minimum inhibitory concentration (MIC) of sodium lactate and sodium chloride for spoilage organisms and pathogens at different pH values and temperatures. J. Food Prot. 59(12):1300-1304.

Kemp R J, Ockerman H W, Krol B, Moerman P C, and Plimpton R F. 1978. Effects of curing ingredients and holding times and temperatures on organoleptic and microbiological properties of dry-cured sliced ham. J. Food Sci. 40:634.

Mbandi E and Shelef L A. 2001. Enhanced inhibition of *Listeria monocytogenes* and *Salmonella* Enteritidis in meat by combinations of sodium lactate and diacetate. J. Food Prot. 64:640-644.

Mbandi E and Shelef L A. 2002. Enhanced antimicrobial effects of combination of lactate and diacetate on *Listeria monocytogenes* and *Salmonella* spp. in beef bologna. Int. J. Food Micro. 76:191-198.

Meilgaard M, Civille G V and Carr B T. Sensory Evaluation Techniques 2nd ed. Boca Raton, FL. CRC Press, Inc.

Miller A J. 1992. Combined water activity and solute effects on growth and survival of *Listeria monocytogenes* Scott A. J. Food Prot. 55:414-418.

Miller R K and Acuff G R. 1994. Sodium lactates affects pathogens in cooked beef. J. Food Sci. 59:15-19.

Murano E A and Rust R E. 1995. General microbial profile of low-fat frankfurters formulated with sodium lactate and a texture modifier. J. Food Quality 18 (4):313-323.

Nerbrink E, Borch E, Blom H and Nesbakken T. 1999. A model based on absorbance data on the growth rate of *Listeria monocytogenes* and including the effects of pH, NaCl, Na-lactate and Na-acetate. Int. J. Food Micro. 47(1/2):99-109.

Palumbo S A and Williams A C. 1994. Control of *Listeria monocytogenes* on the surface of frankfurters by acid treatments. Food Micro. 11(4):293-300.

Ryser E T and Marth E H. 1999. *Listeria, Listeriosis and Food Safety*. New York, Marcel Derkker.

SAS. 1995. SAS User's Guide: Statistics. SAS Institute, Inc., Cary, NC.

Shelef L A and Yang Q. 1991. Growth suppression of Listeria monocytogenes by lactates in broth, chicken and beef. J. Food Prot 54:283-287.

Shelef L A. 1994. Antimicrobial effects of lactate: a review. J Food Prot 57(5):445-450.

Stekelenburg F K and Kant-Muermans M L T. 2001. Effects of sodium lactate and other additives in a cooked ham product on sensory quality and development of a strain of *Lactobacillus curvatus* and *Listeria monocytogenes*. Int. J. Food Micro. 66:197-203.

Walker S J, Archer P and Banks J G. 1990. Growth of *Listeria monocytogenes* at refrigeration temperature. J. Appl. Bacteriol. 68:157-162.

Woolford G, Cassens R G. 1977. The fate of sodium nitrite in bacon. J. Food. Sci. 42:586.

Colorado AES Projects 2003-2004

Title | Investigators | Department | Objectives | Approach
Keywords | Progress Reports | Impact Statements | Publications

Project * COL00740

Title **Development of Technologies for Meat Products of Acceptable Wholesomeness, Shelf-Life and Safety**

Investigator(s) Sofos, JN; Schmidt, GR; Smith, GC;

Department Animal Science

Objectives Meat safety has been at the forefront of societal concerns in recent years as the number and complexity of food safety issues have increased substantially. Animals, which are the reservoir for bacterial foodborne pathogens of enteric origin, are considered as the major source of bacteria that cause current food safety concerns. Feces from animals that harbor foodborne pathogens contaminate meat and/or contaminate the environment resulting in cross-contamination of other foods. The importance of microbial meat safety has been emphasized in recent years through activities and initiatives undertaken by regulatory and public health agencies, and by those in the meat industry. Such initiatives include application of new meat inspection regulations, based on the principles of hazard analysis critical control point (HACCP) and the National Food Safety Initiative . One reason for the increased importance of the issue of meat safety is the emergence or re-emergence of certain pathogenic microorganisms (e.g., Escherichia coli O157:H7, Listeria monocytogenes, Campylobacter jejuni/coli, and Salmonella Typhimurium DT104). Other important causes of increased concern about meat safety are the potential development of resistance, by pathogenic bacteria, to antibiotics and to the traditional food preservation barriers of acidity, heat, cold, dryness and chemical preservatives; the increased ability of some pathogens to cause diseases; changes in practices associated with production, processing distribution, handling and serving of food; and the increased numbers of people with weak immune systems. Therefore, there is a need to address the issue of food safety in order to help the animal and meat industries to provide consumers with meat products of acceptable quality and safety. The overall objective of this project is to conduct research studies that will generate knowledge useful in the development of technologies needed for the production of animal products that are wholesome, of acceptable quality and safe. In general, the studies will evaluate the influence of parameters associated with production (e.g., animal types, handling, feeding, stressing) , processing (e.g., decontamination interventions, thermal processing, preservatives), storage (e.g., refrigerated, frozen or under abuse conditions), and preparation practices (e.g., sanitation, cooking, reheating) on the safety, shelf-life and quality of meat products. Specific objectives are to: (1) examine contamination sources, (2) develop intervention processes (e.g., thermal, chemical) for eliminating/reducing contamination in meat products, (3) examine the impact of processes and environmental variables on resistance development in bacteria, (4) evaluate the influence of environmental and processing variables on the quality of

meat products, (5) assess risk factors (e.g., animal type, stressing, processing, abuse) for their contribution to the development of food safety problems in meat products, (6) design hazard analysis critical control point (HACCP) systems to enhance meat product safety, and (7) disseminate the information generated for use by regulatory authorities, industry and consumers.

Approach

In order for the industry as well as regulatory and public health agencies to provide control systems and guidelines for enhancement of the safety of our meat supply, new knowledge is needed to better understand sources, properties, and control strategies for bacterial pathogens. Exploratory studies will be conducted with the employment of test-tube and model system experiments, while meat products, evaluated in the laboratory or in the field, on pilot plant or commercial scale, will be used to further examine and evaluate variables with the potential of enhancing the wholesomeness, quality, shelf-life and safety of our meat supply. Specific analytical methods and procedures will depend on objectives of individual experiments and will be selected from officially approved methodologies and research publications, or will be developed in the laboratory. The approach of the project will be to design studies that will generate knowledge beneficial to meat producers, processors, regulators and consumers by examining: (1) the ecology and rate of incidence of indicator and important bacteria of public health concern in live meat animals and in their environment, as well as, at various stages of the chain from slaughter through processing, and preparation for consumption, (2) the impact of animal production practices (e.g., feeds, housing, water, manure) on extent of carcass and/or meat product contamination with pathogenic bacteria, as well as the potential for pathogen control in and on live animals through various interventions associated with production practices (e.g., feeding practices, bedding, cleanliness, dehairing), (3) the effect of animal handling practices prior to slaughter on extent of bacterial pathogen contamination on the animals and association of live animal contamination with that on resulting carcasses and meat, (4) the impact of physical (e.g., heat, steam), chemical (e.g., organic acid, phosphates), and biological (e.g., bacteriocin preparations) decontamination and pathogen control processes on levels of bacterial contamination in resulting meat, (5) the control of pathogens in meat products, through various ingredient formulations including preservatives, and multi-intervention procedures including post-packaging pasteurization, (6) the potential for resistance development by microorganisms following exposure to factors such as antibiotics, decontaminants, heat, cold and chemical preservatives, and the potential of preservation hurdles to control resistant pathogenic bacteria, (7) the development and evaluation of sampling and microbiological analytical methods in meat products to better monitor incidence of pathogens, and successful preservation processes and HACCP programs, and (8) the potential for microbial interactions (e.g., competition between pathogenic and nonpathogenic bacteria) in meat products and their impact on product shelf-life and safety. The conclusions generated will be incorporated into HACCP programs for industry and regulatory use in order to enhance the quality, wholesomeness, shelf-life and safety of fresh and processed meat products.

Keywords

food safety, meat products, food microbiology, shelf life, meat quality, product development, microbial interactions, meat processing, bacterial contamination, pork, mutton, decontamination, new technology, enteric bacteria, detection, escherichia coli,

listeria monocytogenes, campylobacter jejuni, salmonella typhimurium, antibiotic resistant organisms, food preservation, food handling

Progress Reports

1993 Sodium lactate (1.8% w/w), sodium erythorbate (0.1% w/w), kappa-carrageenan (1% w/w), and the alginate meat binder (0.4% w/w, sodium alginate; 0.6% w/w lactic acid; and 0.075% w/w calcium carbonate) were studied for their effect on Listeria monocytogenes in raw and cooked ground beef stored aerobically at 4 C. There was no significant (P>.05) increase in numbers of L. monocytogenes during storage of raw ground beef. However, L. monocytogenes numbers were generally lower in treatments with sodium lactate, and higher in sodium erythorbate compared to controls and meat with other additives. Cooking meat to 65 C resulted in less destruction (0.56 and 1.18 log CFU/g) in samples with added alginate meat binder and kappa carrageenan, respectively, compared to the control. Survivors (2.11-3 .73 log CFU/g) decreased initially and then increased slightly, but not significantly (P>.05) during storage (4 C, 6 d) of the cooked products. Samples (110g) of raw (17.2-22.6% fat) and cooked (12.6-16 .4% fat) ground beef in plastic cups were stored aerobically at 4+-1 C . Lipid oxidation was measured by 4 versions of the thiobarbituric acid (TBA) test, including aqueous acid extraction-C18 (TBA-C18), direct heating, distillation and unmodified aqueous acid extraction; and by sensory evaluation of rancid odor after 0, 2, 4, 6 and 8 days of storage. The TBA-C18 method was more specific (P<.05) and its limit of determination was 2 times lower than the other methods in detecting malonaldehyde.

1994 Lag phase duration (LPD) and generation time (GT) values at a given temperature were lower for Listeria monocytogenes compared to other Listeria spp. At 4C, LPDs for L. monocytogenes strains ranged from 69 .8 to 270.8 h. Of the L. monocytogenes cultures tested, strain Scott A had the longest average (209.8+-0.1 h) LPD at 4C. At 10C, LPDs ranged from 36.5 to 68.9 h, with Scott A being again one of the strains with the longest LPD (62.80.7 h). Addition of 0.5% sodium acetate, 2.0% sodium lactate, or 0.26% potassium sorbate significantly (p<0.05) decreased growth of L. monocytogenes in refrigerated turkey bologna which was surface-inoculated after thermal processing and slicing. A national audit of injection-site blemishes in beef top sirloin butts indicated that the incidence was 10.8+-72.99%, with an average weight per blemish of 123.39+-5.48 g. Effects of kappa-carrageenan (KC) on cooking yield and texture were most pronounced at the lowest NaCl level (1%) and the highest cooking temperature (83C). KC also reduced purge of vacuum-packaged slices during refrigerated storage of restructured beef rolls. The use of Na-alginate/Ca-lactate as a binder for veal leg meat increased (P<0.05) binding force and sensory score of bind and decreased cooking loss when used at 0.4%.

1995 Microbiological and visual evaluations were performed to compare the efficacy of hand trimming, spray washing, or a combination of treatments, in the removal of bacteria and fecal material from beef adipose tissue. Hand trimming followed by spray washing compared to spray washing alone were similar in their effectiveness for reduction of microbiological contamination and slightly different in the extent of fecal material removal. Overall, however, higher spray washing pressures (20.68 or 27.58 bar) were more effective (P<0.05) than the lower spray washing pressures (2.76 or 13.79 bar) in removing fecal material from and reducing bacterial numbers on adipose tissue

samples . Reduction in counts was influenced by water temperature (16 to 74deg .C), type of chemical solution and sequence of spray application. In general, water of 74deg.C caused reductions ($P<0.05$) exceeding 3.0 log CFU/cm2, which were higher than those achieved by trimming and spray washing. No spreading of bacteria in areas immediately adjacent to the inoculation site was detected following spray-washing.

1996 Studies compared procedures and interventions for removing physical and bacterial contamination from beef carcasses. Treatment procedures included trimming, washing, and the current industry practice of trimming followed by washing. In addition, hot (74 to 87.8 degrees C at the pipe) water washing and rinshing with ozone (0.3 to 2.3 ppm) or hydrogen peroxide (5%) were applied as intervention treatments. Average reductions in aerobic plate counts were 1.85 and 2.00 log CFU/cm2 for the treatments of trimming-washing and hot-water washing, respectively. Hydrogen peroxide and ozone reduced aerobic plate counts by 1.14 and 1.30 log CFU/cm2. In general, trimming and washing of beef carcasses consistently resulted in low bacterial populations and scores for visible contamination. However, the data also indicated that hot (74 to 87.8 degrees C at the pipe) water washing was an effective intervention that reduced bacterial and fecal contamination in a consistent manner.

1997 Bacterial contamination of meat animals may be transferred to the resulting carcasses during slaughter, which subsequently may contaminate meat products and lead to consumer foodborne illness. Therefore, there is a need to control or reduce carcass contamination in order to decrease the probability of foodborne illness. Studies under this project have examined attachment of bacteria to beef carcass tissue and the efficacy of various technologies in reducing contamination during slaughter. Attachment strength of Escherichia coli O157:H7 cells was similar on beef muscle and adipose tissue, irrespective of culture preparation substrate (broth or cattle manure) . Evaluation of two carcass steam-vacuum spot-decontamination systems indicated that both were at least equally as effective as knife-trimming in removing visible contamination and in reducing counts of bacteria. Knife-trimming and steam-vacuuming reduced average coliform counts by 1.4-1.6 and 1.6-1.7 log colony forming units per square cm, respectively. These results were considered in the approval of steam-vacuuming as a carcass spot-decontamination treatment in the United States. Results of another study indicated that major decontamination of whole beef carcasses could be achieved by knife-trimming followed by spray-washing or by spray-washing followed by hot water-rinsing. The results of these studies are useful to regulatory authorities and the industry as they try to apply procedures to improve the microbiological status of meat and the safety of the resulting products.

1998 The Food Safety and Inspection Service of the United States Department of Agriculture requires removal of fecal, ingesta and other contamination from carcasses during slaughter in order to minimize presence of pathogenic bacteria such as Escherichia coli O157:H7. Studies were conducted to evaluate the effectiveness of decontamination processes on beef carcass tissue inoculated with E. coli. Spray-washing/rinsing treatments utilizing warm/hot water and/or acetic acid solution were evaluated separately and in sequence. Treatments reduced the aerobic plate counts (APC) and E. coli counts of samples inoculated with 5.0-7.4 logCFU/cm2 (APC) by 1.1 to 4.3 logs . Similarly, most treatments reduced total coliform counts of samples inoculated to have

1.8-3.7 logCFU/cm2 (APC) by 0.1 to 1.7 logs. Use of sequential multi-hurdle combinations was more effective in reducing microbial contamination than were individual decontamination treatments. The treatment combination of pre-evisceration washing/acetic acid rinsing/final carcass washing/acetic acid rinsing resulted in the greatest reductions of bacterial numbers. The results of these studies are useful in the selection of decontamination interventions as meat processors develop procedures to meet the requirements of the new inspection regulations. Another study was designed to determine populations of aerobic bacteria, coliforms, sorbitol-negative bacteria including E. coli O157:H7, and Listeria monocytogenes during display at 4C and 12C of ground beef patties made with meat from animals fed diets supplemented daily (for 100 days) with 0, 1000 or 2000 IU of vitamin E. Feeding animals supplemental vitamin E results in its higher accumulation in the muscles, which reduces rates of lipid and pigment oxidation in resulting meat. Reduced oxidation allows longer maintenance of acceptable meat color, which is desirable for long-term overseas export of meat and for longer display by retailers. However, it is of concern whether the longer visual acceptability is associated with higher microbial contamination. This study evaluated patties, visually, for overall appearance, and analyzed samples for microbiological counts. High vitamin E beef maintained acceptable color longer than did product from animals fed the control diet, but effects on microbiological counts were less pronounced. In general, use of high-vitamin E versus control beef in patty manufacture had no major effect on populations of aerobic bacteria, coliforms, sorbitol-negative bacteria, or L. monocytogenes during display at 4C or 12C. Even though increases in bacterial counts were similar, retailers of meat products from animals fed supplemental vitamin E should be instructed against displaying the products for periods of time longer than those used for products from control animals. Products stored for longer periods of time, due to acceptable appearance, may carry higher bacterial populations. The results of these studies are important to producers, processors and consumers because they should contribute to the supply of our society with meat products of better quality and microbial food safety.

1999 Increased consumer concern about microbial foodborne illness has led to establishment of new meat and poultry inspection regulations in the United States. The new regulations require that meat and poultry products meet established microbiological performance criteria for Escherichia coli and standards for Salmonella contamination. Companies that do not meet the established criteria need to apply procedures that reduce contamination. Therefore, studies were conducted to determine microbiological baselines and the influence of decontamination processes on the bacterial load of carcasses in seven beef slaughtering plants of the United States. Carcasses were sampled according to procedures described in the meat and poultry inspection regulation. Samples (3,780) were taken from each plant at pre-evisceration, final carcass washing and after 24 hours of carcass chilling during November through January (wet season) and May through June (dry season). The samples were analyzed individually for aerobic plate counts (APC), total coliform counts (TCC), Escherichia coli counts (ECC) and for presence of Salmonella. Incidence of Salmonella was higher in dry feces of older compared to younger animals, fresh feces of younger compared to older animals and on cow/bull carcasses compared to steer/heifer carcasses. Most factors and their interactions had significant (P less than 0.05) effects on the bacterial counts obtained. Compared with regulatory requirements, results showed that, on

average, and depending on plant and season, 84 .2 to 100 percent of the chilled carcasses sampled were in the acceptable range. The corresponding values before carcass decontamination were 51.1 to 91.1 percent, demonstrating the contribution of decontamination processes in reducing carcass contamination. Depending on plant and season, the overall probabilities of chilled carcasses passing the regulatory requirements for Escherichia coli at chilling were 0.597 to 1.0 for the brisket, 0 .471 to 1.0 for the flank and 2.485 to 1.0 for the rump. After 24 hours of chilling, average incidence (percent) of Salmonella in the brisket, flank and rump samples, respectively, for steer/heifer carcasses was 0.8, 0, and 2.5 for the wet season and 0.8, 0 and 0 for the dry season. When the numbers of Salmonella positive brisket, flank and rump samples were combined, the probabilities of passing the regulatory requirements were 0.242 to 1.0 and 0.772 to 1.0 for the wet and dry season, respectively in steer/heifer plants, and 0.368 to 0 .974 and 0.865 to 1.0 in cow/bull plants. Correlation coefficients of APC, TCC, and ECC with Salmonella incidence were higher (P less than 0 .05) for cow/bull samples that had increased incidence of the pathogen compared to steer/heifer samples. The results indicated substantial variation among plants and between seasons in meeting Escherichia coli performance criteria and Salmonella contamination standards. The data also demonstrated the value of decontamination processes in reducing microbial loads and should serve as a baseline for future comparisons in measuring the microbiological status of beef carcasses, as the new inspection requirements are implemented.

2000 Public concern about microbial contamination of meat products and associated outbreaks of foodborne illness have emphasized the need for research to improve the microbiological quality of the products. Increased levels of microbial contamination and presence of pathogens may lead to foodborne illness and associated fatalities, loss of product quality, reduced product exports and associated economics losses. Therefore, studies were conducted: (1) to determine changes in microbiological populations of animal hides and beef carcasses at different stages of the slaughtering process in eight plants employing sequential, multiple intervention decontamination technologies; and (2) to evaluate decontamination intervention technologies, previously shown to be efficacious for decontaminating carcasses for potential use on beef variety meats. Multiple-sequential interventions were applied commercially to reduce beef carcass contamination in eight packing plants. Sponge swab samples were plated for microbial analysis of total plant counts (TPC), total coliform counts (TCL) and E. coli counts (ECC), while additional samples were analyzed for Salmonella. Overall TPC, TCC and ECC on the animal hide were in the ranges of 8.2 to 12.5, 6.0 to 7.9, and 5.5 to 7.5 log colony forming units per cm2 (log CFU/cm2), respectively. The corresponding levels of contamination on carcass surfaces before application of decontamination interventions were 6.1 to 9.1, 3.0 to 6.0, and 2.6 to 5.3 log CFU/cm2, respectively. Immediately after application of decontamination interventions, such as steam-vacuuming, pre-evisceration carcass washing or organic acid solution rinsing, post-evisceration carcass washing, hot water carcass washing, or organic acid rinsing, mean TPC, TCC and ECC on carcass surfaces were 3.8 to 7.1, 1.5 to 3.7 and 1.0 to 3.0 log CFU/cm2, respectively. Finally, after a period of 24 to 36 hours of chilling the counts on carcasses were 2.3 to 5.3, 0.9 to 1.3, and 0.9 log CFU/cm2, respectively. The overall incidence of Salmonella was 15.4% on animal hide samples and 1.3% on chilled carcass samples. The results demonstrated that application of decontamination

technologies, in a multiple-intervention sequence, during beef slaughter is effective in reducing bacterial contamination and improving the microbiological quality of beef carcasses. In addition, application of interventions such as acetic acid (2%), lactic acid (2%) trisodium phosphate (12%) and hot water (78 degrees C) for 10 seconds effectively reduced TPC, TCC and ECC on six variety meats (beef cheek meat, large intestine, lips, liver oxtail, and tongue). These results indicated that interventions applied to decontaminate beef carcasses can also be considered for application to decontaminate variety meats; however, their application should be optimized to prevent undesirable effects on product quality. The implementation of the hurdle-technology concept of sequential meat decontamination in association with the hazard analysis critical control point (HACCP) system of process control should aid in reducing microbial contamination and in meeting performance criteria established by inspection regulations.

2001 Bacterial foodborne illness outbreaks have been a major concern for the industry, regulatory authorities and consumers of meat products, and have emphasized the need for research to address issues associated with prevalence and control of pathogens in meat products. Therefore, studies were conducted to: 1) evaluate sponge-swabbing and tissue-excising procedures for microbiological analysis of beef carcasses; 2) determine microbiological populations and pathogen incidence on beef carcasses and fresh beef cuts; and, 3) determine if live animal characteristics were associated with levels of microbial contamination on resulting carcasses from dairy cows. Carcass samples obtained by sponging had higher (P less than 0.05) aerobic plate counts (APC) - 35 degrees C than excised samples, whereas carcass APC - 25 degrees C were similar. Total coliform counts (TCC) and Escherichia coli counts (ECC) were higher in excised samples than in samples obtained by sponging. The fat surface of the clod at the plant had higher APC - 25 degrees C than the lean, whereas differences between the two surfaces of the top butt were minor. Although bacterial populations showed only minor changes during transportation of subprimals, retail cuts stored for 48 h at 4 to 5 degrees C had APC - 25 degrees C, TCC and ECC higher than counts of comparable retail samples immediately after cutting. No samples were positive for Salmonella spp. or Staphylococcus aureus, whereas Listeria monocytogenes was found on clods and top butts at the plant (2.0 to 8 .3 percent) and on subprimal top butts at retail (28.6 percent), but not on steaks - roasts at retail. During a 3-day period, 80 live cull dairy cows were weighed and scored for ambulatory status, body condition, hide cleanliness and fecal matter consistency, and their carcasses were weighed and, later, graded. Carcasses were sampled for APC, TCC and ECC. Excised (100 cm2) samples were taken prior to evisceration, after final carcass washing and after carcass chilling, from the brisket and the round. In addition, samples of fresh feces, sponge-swab samples from hide surfaces, and samples of excised carcass tissues were analyzed for Salmonella and Escherichia coli O157:H7. Factors having significant (P less than 0.05) effects on bacterial populations of carcasses immediately after hide removal were sampling date (APC, TCC) and lot number (APC, TCC). Factors significantly affecting bacterial counts after final carcass washing were lot number (APC, TCC, ECC), ambulatory status (APC, TCC) and hide cleanliness (TCC). Characteristics having significant (P less than 0.05) effects on microbial counts after carcass chilling were sampling date (APC, TCC) and lot number (APC, TCC). No samples were positive for E. coli O157:H7, whereas Salmonella was detected in 0, 13.8 and 1.2 percent of fecal (N = 77), hide (N = 80) or

carcass (N = 427) samples, respectively. Although microbial contamination on dairy cow carcasses differed among sampling dates and lots of cattle, live animal scores for ambulatory status, body condition, hide cleanliness and fecal matter consistency were of no use in identifying cattle likely to produce contaminated carcasses.

2002 Listera monocytogenes has reemerged as an important meat borne pathogen in the United States after major outbreaks of illness that occurred in 1998-1999 and 2002 through consumption of post-processing contaminated ready-to-eat meat and poultry products. These outbreaks resulted in hundreds of cases of illness and numerous deaths in several states, and in recalls of millions of pounds of potentially contaminated products. Since the pathogen is ubiquitous in the environment it may contaminate foods pre- and post-processing. Of major concern is accidental contamination of ready-to-eat products after processing. Listeria monocytogenes may increase to high populations even during refrigerated and vacuum-packaged storage of products such as frankfurter and bologna type sausages that may be contaminated during peeling, slicing and repackaging after heat processing. Post-processing contamination of vacuum-packaged, ready-to-eat meat products with Listeria monocytogenes may present a serious health risk, requiring effective pre- or post-packaging technologies to inhibit growth of the pathogen during product storage, distribution and retailing, or to eliminate the pathogen before consumption. Studies were conducted to determine the effectiveness of combinations of antimicrobials included in the formulation of frankfurters against Listeria monocytogenes inoculated (3 to 4 log colony-forming-units - CFU/square centimeter) on their surface after peeling and before vacuum packaging. In addition, the antilisterial effect of immersing the packaged products, prepared with or without antimicrobials, in hot (75 or 80 degrees Celsius - C) water for 30 to 90 seconds was evaluated. Samples were stored at 4 C for 120 days and periodically analyzed for pH and for microbial growth on tryptic soy agar with added 0.6 percent yeast extract and on PALCAM agar. Sodium lactate (1.8 percent; 3 percent of a 60 percent commercial solution) used alone inhibited growth of Listeria monocytogenes for 35 to 50 days, whereas when used in combination with 0.25 percent sodium acetate, sodium diacetate or glucono-delta-lactone (GDL), it inhibited growth throughout storage (120 days). Immersing packaged frankfurters in hot water (80 C) for 60 seconds reduced initial populations of Listeria monocytogenes by 0.4 to 0.9 log CFU/square centimeter and reduced its growth by 1.1 to 1.4 log CFU/ square centimeter at 50 to 70 days of storage in samples containing 1.8 percent sodium lactate alone. However, immersion of frankfurters containing no antimicrobials in hot water (75 or 80 C) did not inhibit growth for more than 10 to 20 days, unless one frankfurter was packaged per bag and heat-treated for 90 seconds. The results indicated that inclusion of 1.8 percent sodium lactate with 0.25 percent sodium acetate, sodium diacetate, or GDL in cured meat formulations may control Listeria monocytogenes growth during extended refrigerated (4 C) storage. Additional studies are required to evaluate the effects of combinations of antimicrobial hurdles at abusive temperatures of storage, as well as in additional processed meat formulations and on the sensory quality and shelf life of the products.

Impact

1999 There was major variation among beef slaughtering plants in levels of microbiological contamination and incidence of Salmonella on beef carcasses, indicating that certain

operators will have difficulties in meeting regulatory requirements for microbiological performance criteria. Since decontamination processes improved probabilities of meeting regulatory criteria, individual plants need to select decontamination procedures that will reduce microbial contamination and should lead to cleaner meat products for consumers.

2000 The exterior hide and hair of beef animals are highly contaminated with bacteria, including pathogens, and may serve as sources of contamination for the plant environment and the resulting carcasses and meat products. Commercial application of decontamination technologies in a sequential order during beef slaughter, reduced contamination of carcasses and associated variety meats, and should aid in enhancing food safety.

2001 Animals entering the slaughtering process introduce microbial contamination, including bacterial pathogens, which are transferred on carcasses and meat products during slaughter and processing. Appropriate methods of sampling and testing are necessary to detect sources and extent of such contamination. Such methods are also necessary to determine the effect of interventions in reducing or controlling contamination with spoilage and pathogenic bacteria. Evaluation of sources of contamination and methods for its control contribute to the enhancement of the safety of our meat supply.

2002 According to data published by the Centers for Disease Control and Prevention (CDC) the pathogen, Listeria monocytogenes, is responsible for approximately 2,500 cases of illness, 2,300 hospitalizations and 500 deaths in the United States annually, as well as numerous recalls of potentially contaminated commercial ready-to-eat products. Major recent outbreaks of listeriosis have been associated with consumption of commercially processed ready-to-eat meat and poultry products. The results of studies demonstrated that Listeria monocytogenes post-processing contamination of frankfurters may be controlled during extended product storage by inclusion in their formulation of appropriate combinations of the preservatives lactate, acetate, diacetate and glucono-delta-lactone. The results of these studies should be useful to the meat industry and regulators as they develop new strategies for control or delay of growth of deadly Listeria monocytogens bacteria in ready-to-eat meat products.

Publications

1993 BOYLE, E.A.E. ET AL. 1993. Depression of aw by soluble and insoluble liquids in alginate restructured beef heart meat. J. Food Sci. 58:959-962, 967.

DEXTER, D.R. ET AL. 1993. Quality characteristics of turkey bologna formulated with carrageenan, starch, milk and soy protein. J. Muscle Foods 4:207-223.

ESTELA, L.A. ET AL. 1993. Comparison of the conventional and reversed phage-typing procedures for identification of Listeria spp. Appl. Envir. Microb. 59:617-619.

HARMAYANI, E. 1993. Reduction of cholesterol levels in fat with biological systems. Ph.D. Dissertation. Colorado State University, Fort Collins, 201 p.

HARMAYANI, E. ET AL. 1993. Fate of Listeria monocytogenes in raw and cooked ground beef with meat processing additives. Int. J. Food Microbiol. 18:223-232.

RAHARJO, S. ET AL. 1993. Effects of meat curing agents and phosphates on thiobarbituric acid (TBA) numbers of ground beef determined by the aqueous acid extraction TBA-C18 method. Food Chem. 47:137-143.

RAHARJO, S. ET AL. 1993. Measurement of lipid oxidation in beef with four thiobarbituric acid (TBA) methods. J. Food Sci. 58:921-924, 932.

RAHARJO, S. ET AL. 1993. Methodology for measuring maldonaldehyde as a product of lipid peroxidation in muscle tissues: A review. Meat Sci. 35:145-169.

SHAND ET AL. 1993. Properties of algin/calcium and salt/phosphate structured beef rolls with added gums. J. Food Sci. 58:1224-1230.

SOFOS, J.N. 1993. Current microbiological considerations in food preservation. Int. J. Food Microbiol. 19:87-108.

1994 BARBOSA, W.B., L. CABEDO, H.J. WEDERQUIST, J.N. SOFOS and G.R. SCHMIDT . 1994. Growth variation among species and strains of Listeria in culture broth. J. Food Prot. 57:765-769, 775.

BARKANS, D.E. and J.N. SOFOS. 1994. Potential for growth of Listeria monocytogenes in beef with raw green peppers and onions. 54th Annual Mtg. of the Inst. of Food Technologists, June 25-29, Atlanta, GA. Abstr. No. 59C-6.

BOND, F.L., C.R. KIESSLING, K.S. KREUZER and J.N. SOFOS. 1994. Detection and quantification of chlortetracycline in catfish. Food and Drug Administration Laboratory Information Bulletin 10(1-6), No. 3853.

CABEDO, L., J.N. SOFOS, et al. 1994. Comparison of bacterial growth in beef from animals fed diets without or with added vitamin E. 54th Annual Meeting of the Inst. of Food Technologists, June 25-29, Atlanta , GA. Abstr. No. 66-3.

DEXTER, D.R. 1994. Quality characteristics of fresh and freeze-dried restructured meat products. Ph.D. Dissertation. Colorado State University, Fort Collins.

DEXTER, D.R., G.L. COWMAN, J.B. MORGAN, R.P. CLAYTON, J.D. TATUM, J.N. SOFOS, G.R. SCHMIDT, R.D. GLOCK and G.C. SMITH. 1994. Incidence of injection-site blemishes in beef top sirloin butts. J. Anim. Sci. 72:824-827. --

GONZALES, E.D. et al. 1994. Comparison of the standard aerobic plate count method and the PetrifilmTM aerobic count method for use in the hard surface carrier test method for testing disinfectants. FDA Lab Inf Bull. 10(1-6), 3870.

HAGEN, C.J., E.M. SLOAN, G.A. LANCETTE, J.T. PEELER and J.N. SOFOS. 1994. Enumeration of Vibrio parahaemolyticus and Vibrio vulnificus in various seafoods with two enrichment broths. J. Food Protect. 57:403-409

HEATON-CORNELIUS, K. 1994. Residue testing in pork; and residues of antibiotics, hormones and pesticides in conventional, natural and organic beef. M.S. Thesis, Colorado State University, Ft. Collins

LOFTIS, M., C.R. KIESSLING, W.M. KIESSLING, E.D. GONZALES, J.H. CUTTING, F.L. BOND, K.S. KREUZER and J.N. SOFOS. 1994. Use of computer programs to replace hand- graphing in calculation of microbiological antibiotic assays. Food and Drug Administration Laboratory Information Bulletin 10(1-6), No. 3842.

RAHARJO, S., D.R. DEXTER, R.C. WORFEL, J.N. SOFOS, M.B. SOLOMON, G.W. SHULTS and G.R. SCHMIDT. 1994. Restructuring veal steaks with salt/ phosphate and sodium alginate/calcium lactate. J. Food Sci. 59:471-473.

SCHMIDT, G.R., J.N. SOFOS and J.A. PEREJDA. 1994. Use of starches to enhance cooking yields and binding of algin/calcium restructured beef. Proc. 40th Intl. Congress of Meat Sci. and Technol. The Hague, The Netherlands. August 28-September 2.

SCHMIDT, G.R., J.N. SOFOS and J.A. PEREJDA. 1994. Use of starches to enhance cooking yields and binding of algin/calcium restructured beef. 40th Int. Congress Meat Sci. Technol., 8/28-9/2, The Hague, The Netherlands.

SCHMIEG, J.A., et al. 1994. Recovery of Escherichia coli and Staphylococcus aureus using phosphate buffered saline vs. Butterfield's phosphate buffer in MPN dilutions. FDA Laboratory, Information Bulletin 10(1-6), No. 3871.

SHAND, P.J., J.N. SOFOS and G.R. SCHMIDT. 1994. Differential scanning calorimetry of meat/kappa-carrageenan mixtures. J. Food Sci. 59:711-715.

SHAND, P.J., J.N. SOFOS and G.R. SCHMIDT. 1994. Kappa-carrageenan, sodium chloride and temperature affect yield and texture of structured beef rolls. J. Food Sci. 59:282-287.

SMITH, G.C., J.B. MORGAN, J.N. SOFOS and J.D. TATUM. 1994. Feeding of supplemental vitamin E and its effect on meat quality. Presented at 3rd Int. Food Production Confer. Milano, Italy, February 22-23, pp. 35-36.

SMITH, G.C., J.B. MORGAN, J.N. SOFOS and J.D. TATUM. 1994. Supplemental vitamin E in beef cattle diets to improve shelf-life of beef. Proceedings of the Eastern Nutrition Conference, Canadian Feed Industry Association, April 19-23, College Inn, Guelph, Ontario, Canada, pp. 123-131.

SMITH, G.C., J.B. MORGAN, J.N. SOFOS, J.D. TATUM and G.R. SCHMIDT. 1994. Quality and shelf-life of beef from animals fed supplemental vitamin E. 40th Int. Congress Meat Sci. Technol., 8/28-9/2, The Hague, The Netherlands.

SMITH, G.C., J.B. MORGAN, J.N. SOFOS, J.D. TATUM and G.R. SCHMIDT. 1994. Quality and shelf-life of beef from animals fed supplemental vitamin E. Proc. 40th Intl. Congress of Meat Sci. and Technol. The Hague, The Netherlands. August 28-September 2.

SMITH, G.C., J.N. SOFOS, J.B. MORGAN, M.J. AARONSON, R.P. CLAYTON, D.K . JONES, J.D. TATUM and G.R. SCHMIDT. 1994. Ensuring the safety of the meat supply. Proc. Reciprocal Meat Conference. Pennsylvania State University, University Park, PA, June 13, 1994

SMITH, G.C., J.N. SOFOS, M.J. AARONSON, J.B. MORGAN et al. 1994. Incidence of pesticide residues and residues of chemicals specified for testing in U.S. beef by the European Community. J. Muscle Foods 5:271-284.

SOFOS, J.N. 1994. Antimicrobial agents. In Handbook of Toxicology, Volume 1, Food Additive Toxicology. A.T. Tu and J.A. Maga, Editors. Marcel Dekker, Inc., Book Company, New York, NY. pp. 501-529.

SOFOS, J.N. 1994. Microbial growth and its control in meat, poultry and fish. In Advances in Meat Research, vol. 9. A.M. Pearson and T.R. Dutson, Editors. Chapman and Hall, Glasgow, U.K., pp. 353-403.

SOFOS, J.N. and S. RAHARJO. 1994. Curing agents. In Handbook of Toxicology, Volume 1, Food Additive Toxicology. A.T. Tu and J.A. Maga, Editors. Marcel Dekker, Inc., Book Company, New York, NY. pp. 235-267.

SOFOS, J.N. and S. RAHARJO. 1994. Salts. In Handbook of Toxicology, Volume 1, Food Additive Toxicology. A.T. Tu and J.A. Maga, Editors. Marcel Dekker, Inc., Book Company, New York, NY. pp. 413-430.

SOFOS, J.N., A.S. BA-JABER, G.R. SCHMIDT and G.C. SMITH. 1994. Quality of extrusion cooked poultry meat products. 8th Int'l. Conference: Recent Developments in Food Science and Nutrition. July 6-8, Cos, Greece.

SOFOS, J.N., A.S. BA-JABER, G.R. SCHMIDT and J.A. MORGAN. 1994. Quality of extrusion cooked poultry meat products. 8th Int. Conference: Recent Developments in Food Science and Nutrition, July 6-8, Cos, Greece.

SOFOS, J.N., B.M. SMYTH, C.M. BACCO and G.R. SCHMIDT. 1994. Inhibition of Listeria monocytogenes by preservatives in vacuum-packaged bologna. 40th Int. Congress Meat Sci. Technol., 8/28-9/2, The Hague, The Netherlands.

SOFOS, J.N., B.M. SMYTH, C.M. BACCO and G.R. SCHMIDT. 1994. Inhibition of Listeria monocytogenes by preservation: vacuum-packaged bologna. Proc. 40th Intl. Congress of Meat Sci. and Technol. The Hague, The Netherlands. August 28-September 2.

SOFOS, J.N., J.A. PEREJDA and G.R. SCHMIDT. 1994. Use of starch for water binding in restructured meat products. 8th Int. Conference: Recent Developments in Food Science and Nutrition, July 6-8, Cos, Greece.

SOFOS, J.N., J.A. PEREJDA and G.R. SCHMIDT. 1994. Use of starch for water binding in restructured beef products. 8th Int'l. Conference: Recent Developments in Food Science and Nutrition. July 6-8, Cos, Greece.

SOFOS, J.N., J.B. MORGAN, G.C. SMITH and G.R. SCHMIDT. 1994. Application of HACCP principles in beef slaughter and fabrication. 40th Int. Congress Meat Sci. Technol., 8/28-9/2, The Hague, The Netherlands.

SOFOS, J.N., J.B. MORGAN, G.C. SMITH and G.R. SCHMIDT. 1994. Application of HACCP principles in beef slaughter and fabrication. Proc. 40th Intl. Congress of Meat Sci. and Technol. The Hague, The Netherlands. August 28-September 2.

SOFOS, J.N., R.C. WORFEL, G.C. SMITH, J.B. MORGAN and G.R. SCHMIDT. 1994. The use of wood in meat plants. Meat Focus Int. 3(5):213-217.

SOFOS, J.N., W.B. BARBOSA, et al. 1994. Potential for growth of Listeria monocytogenes in meat and poultry products. 8th Int. Conference: Recent Developments in Food Science and Nutrition, July 6-8, Cos, Greece.

SOFOS, J.N., W.B. BARBOSA, H.J. WEDERQUIST, G.R. SCHMIDT and G.C. SMITH. 1994. Potential for growth and inhibition of Listeria monocytogenes in meat and poultry products. 8th Int'l. Conference: Recent Developments in Food Science and Nutrition. July 6- 8, Cos, Greece.

WEDERQUIST, H.J., J.N. SOFOS and G.R. SCHMIDT. 1994. Listeria monocytogenes inhibition in refrigerated vacuum packaged turkey bologna by chemical additives. J. Food Sci. 59:498-500, 516.

1995 BARBOSA, W.B., SOFOS, J.N., SCHMIDT, G.R. and SMITH, G.C. 1995. Growth potential of individual strains of Listeria monocytogenes in fresh vacuum-packaged ground top rounds of beef. J. Food Prot. 58:398-403

BOND, F.L., SOFOS, J.N., KREUZER, K.S. and KRESSLING, C.R. 1995. An evaluation of the Charm II test for the detection of spectinomycin in raw milk. Food and Drug Administration Laboratory Information Bulletin 10(11), No. 3915

BRENT, J., ET AL. 1995. Botulism from potato salad. Dairy, Food and Environmental Sanitation 15:420-422

CABEDO, L., SOFOS, J.N., MORGAN, J.B., SCHMIDT, G.R. and SMITH, G.C. 1995. Effect of time of exposure of beef fat fascia to Escherichia coli ATCC 11370 on its removal by spray-washing with chemical solutions and 35°C or 74°C water. 82nd Annual Meeting of the International Association of Milk, Food and Environmental Sanitarians. July 30-August 2, Pittsburgh, PA. Abstract No. 89

CABEDO, L., SOFOS, J.N., SCHMIDT, G.R. and SMITH, G.C. 1995. Attachment and removal of Escherichia coli O157:H7 from beef carcass adipose tissue as affected by its exposure to decontaminating agents. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 12B-3

CABEDO, L., SOFOS, J.N., SCHMIDT, G.R. and SMITH, G.C. 1995. Effect of culturing medium on attachment of E. coli O157:H7 onto fat or lean beef tissues. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 12B-2

CABEDO-BOTELLA, L. 1995. Attachment, removal or growth of spoilage bacteria and the pathogens Listeria monocytogenes and Escherichia coli O157:H7 on beef. Ph.D. Diss, Colo State Univ

CANNON, J.E., DELMORE, R.J., MORGAN, J.B., SCHMIDT, G.R., SOFOS, J.N. and SMITH, G.C.. 1995. Characteristics of fresh and cooked pork sausage from pigs supplemented with vitamin E. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 68C-1

CANNON, J.E., MORGAN, J.B., SCHMIDT, G.R., DELMORE, R.J., SOFOS, J.N., SMITH, G.C. and WILLIAMS, S.N. 1995. Chemical, shelf-life and sensory properties of vacuum-packaged precooked pork from hogs fed supplemental vitamin E. Proceedings of the 41st Annual International Congress of Meat Science and Technology, August 20-25. San Antonio, TX . Vol. 2, pp. 370-373

CANNON, J.E., MORGAN, J.B., SCHMIDT, G.R., DELMORE, R.J., SOFOS, J.N., SMITH, G.C. and WILLIAMS, S.N. 1995. Vacuum-packaged precooked pork from hogs fed supplemental vitamin E: Chemical, shelf-life and sensory properties. J. Food Sci. 60:1179-1182

CANNON, J.E., MORGAN, J.B., SCHMIDT, G.R., TATUM, J.D., SOFOS, J.N., SMITH, G.C., HILTON, G.G. and WILLIAMS, S.N. 1995. Growth and fresh-meat quality and characteristics of pigs supplemented with vitamin E. 87th Annual Meeting of the American Society of Animal Science, J. Anim. Sci. Vol. 73, Supplement 1, No. 219

CUTTING, J.H., ET AL. 1995. Agarose gel electrophoretic detection and identification of six beta-lactam antibiotic residues in milk. J. Assoc. Off. Anal. Chem. Int. 78:663-667

CUTTING, J.H., HURLBUT, J.A. and SOFOS, J.N. 1995. Comparison of the AOAC microbiological methodology for detection of penicillin in food with a micellular electrokinetic capillary chromatography method. Food and Drug Administration Laboratory Information Bulletin 10(12), No. 3918

CUTTING, J.H., HURLBUT, J.A. and SOFOS, J.N. 1995. Detection of beta-lactam antibiotics in milk using micellar electrokinetic capillary chromatography (MECC).

109th Annual Meeting of the Association of Official Analytical Chemists. Abstract No. 14-E-007

CUTTING, J.H., SOFOS, J.N. and HURLBUT, J.A. 1995. Evaluation of a micellar electrokinetic capillary chromatography method (MECC) for the quantitation of penicillin G in premix feeds. 109th Annual Meeting of the Association of Official Analytical Chemists. Abstract No. 16-C-001

FITZGERALD, S.K., SHERBECK, J.A., MORGAN, J.B. and SMITH, G.C. 1995. The International Beef Quality Audit. Beef Prog. Rpt. pp. 93-101. Dept . of Animal Sciences, Colorado State University, Ft. Collins

GARCIA, G.R., HAYMOND, R.E., SPRAGUE, D.M., SINGLETON, E.R., PEELER, J .T., LANCETTE, G.A. and SOFOS, J.N. 1995. A comparison of a rapid elevated temperature plate count method with 3- and 5-tube MPN procedures for enumeration of E. coli in soft-shell clams. J. Food Prot. 58:1197-2000

GARCIA, G.R., SINGLETON, E.R. and SOFOS, J.N. 1995. Enumeration of Listeria monocytogenes with a 3-tube MPN procedure and a modified oxford agar plating method. Food and Drug Administration Laboratory Information Bulletin 10(9), No. 3899

GORMAN, B. M. 1995. Reduction of bacterial contamination of beef tissue by trimming and spray-washing. M.S. Thesis, Colo State Univ

GORMAN, B.M., ET AL. 1995. Evaluation of hand-trimming, various sanitizing agents and hot water spray-washing as decontamination interventions for beef brisket adipose tissue. J. Food Prot. 58:899-907

GORMAN, B.M., KOCHEVAR, S.L., SOFOS, J.N., MORGAN, J.B., SCHMIDT, G.R. and SMITH, G.C. 1995. Shelf-life of beef tissue following spray-washing with chemical solutions and 35°C or 74°C water. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 50-9

GORMAN, B.M., MORGAN, J.B., SOFOS, J.N. and SMITH, G.C. 1995. Removal of fecal material from beef adipose tissue and reduction of microbiological counts by trimming or spray-washing. CSU Beef Program Report, pp. 121-126

GORMAN, B.M., MORGAN, J.B., SOFOS, J.N. and SMITH, G.C.. 1995. The effect of pressure, size of fecal contamination and time on removal of fecal material and microorganisms from beef adipose tissue by spray-washing. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 12D-8

GORMAN, B.M., MORGAN, J.B., SOFOS, J.N. and SMITH, G.C. 1995. Microbiological and visual effects of trimming and/or spray-washing for removal of fecal material from beef. J. Food Prot. 58:984-989. --

GORMAN, B.M., SOFOS, J.N., MORGAN, J.B., SCHMIDT, G.R. and SMITH, G.C. 1995. Evaluation of hand-trimming, various sanitizing agents and hot water spray-washing as decontamination interventions for beef brisket adipose tissue. CSU Beef Program Report, pp. 127-132

GORMAN, B.M., SOFOS, J.N., MORGAN, J.B., SCHMIDT, G.R. and SMITH, G.C. 1995. Intervention through use of hand-trimming, chemical sanitizers and hot water spray-washing to remove fecal and microbiological contamination from beef adipose tissue. 82nd Annual Meeting of the International Association of Milk, Food and Environmental Sanitarians. July 30-August 2, Pittsburgh, PA. Abstract No. 98

GRAVES-DELMORE, L.R., EUSTACE, I.M., TREADWELL, V.M., SOFOS, J.N., BARKANS, D.E. and SCHMIDT, G.R.. 1995. Evaluation of the shelf-life and quality of Australian manufacturing beef. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 12D-

HAGEN, C.J. and SOFOS, J.N. 1995. Comparison of three methods for the detection of Listeria monocytogenes in foods. 95th General Meeting of the American Society for Microbiology, May 21-25, Washington, D.C. Abstract No. P57

KALLANDER, K.D., ET AL. 1995. Detection of heated bacterial spores with fluid thioglycollate and soybean casein digest broths containing variable concentrations of solids. J. Food Prot. 58:421-425

KIESSLING, C.R., LOFTIS, M., KREUZER, K.S. and SOFOS, J.N. Comparative evaluation of three rapid test kits with the microbiological disc assay for the detection of six beta-lactam antibiotic residues in milk . Food and Drug Administration Laboratory Information Bulletin 10(10), No. 3904

KOCHEVAR, S.L., SOFOS, J.N., SCHMIDT, G.R. and SMITH, G.C. 1995. Screening the Heliojet as a method for decontaminating beef carcasses. Final report to Helios Research Corp., pp. 1-10. Dept. of Anim. Sci., Colorado State Univ., Ft. Collins

MORGAN, J.B., SMITH, G.C., NEEL, S.W. and BELK, K.E. 1995. International Beef and Pork Quality Audits. Proc. Intl. Congress of Meat Sci. and Technol. (San Antonio, TX). Vol. 41(II), Sect. A, No. 2, pp. 13-18

RAHARJO, S., DEXTER, D.R., WORFEL, R.C., SOFOS, J.N., SOLOMON, M.B., SHULTS, G.W. and SCHMIDT, G.R.. 1995. Quality characteristics of restructured beef steaks manufactured by various techniques. J. Food Sci. 60:68-71

REAGAN, J.O., BUYCK, M.J., NICKELSON, R., ACUFF, G.R., BUEGE, D.R., DICKSON, J.S., KASTNER, C.L., MARSDEN, J.L., MORGAN, J.B., SMITH, G.C. and SOFOS, J.N. 1995. Zero tolerance trimming of beef carcasses. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 62-4

ROMER, J.C., KALLANDER, K.D., SOFOS, J.N., KREUZER, K.S. and SINGLETON , E.R. 1995. Improved detection of heated thermophilic bacterial spores. Food and Drug Administration Laboratory Information Bulletin 10(12), No. 3919

SCHNELL, T.D., SOFOS, J.N., LITTLEFIELD, V.G., MORGAN, J.B. , GORMAN, B.M., CLAYTON, R.P. and SMITH, G.C.. 1995. Effects of post-exsanguination dehairing on the microbial load and visual cleanliness of beef carcasses. J. Food Prot. (in press)

SCHNELL, T.D., SOFOS, J.N., LITTLEFIELD, V.G., MORGAN, J.B., GORMAN, B .M., CLAYTON, R.P. and SMITH, G.C. 1995. Dehairing of beef carcasses as an intervention to reduce microbial load and improve visual cleanliness. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 50-8

SMITH, G.C., MORGAN, J.B., NEEL, S.W. and BELK, K.E. 1995. The International Beef Quality Audit. Proc. Intl. Livestock Congress (2/95 ; Houston, TX). The Houston Livestock Show & Rodeo, and The Texas A&M University System

SMITH, G.C., MORGAN, J.B., SOFOS, J.N., TATUM, J.D. and SCHMIDT, G.R. 1995. Vitamin E and meat quality. Symp. From Feed to Food, 5/17-18, Utrecht, The Netherlands. pp. 1-10

SMITH, G.C., MORGAN, J.B., SOFOS, J.N., TATUM, J.D. and SCHMIDT, G.R. 1995. Vitamin E and meat quality. Symposium From Feed to Food, May 17-18, Utrecht, The Netherlands. pp. 1-10

SMITH, G.C., SOFOS, J.N., MORGAN, J.B. and REAGAN, J.O. 1995. Carcass washing and decontamination of beef carcasses. 55th Annual Meeting of the Institute of Food Technologists, June 3-7, Anaheim, CA. Abstract No. 62-5

SMITH, G.C., SOFOS, J.N., MORGAN, J.B., REAGAN, J.O., ACUFF, G.R., BUEGE, D.R., DICKSON, J.S., KASTNER, C.L. and NICKELSON, R. 1995. Fecal-material removal and bacterial-count reduction by trimming and/or spray-washing of beef external-fat surfaces. Proc. USDA/FSIS Scientific and Technical Conference, New Technology to Improve Food Safety (Chicago, IL)

SOFOS, J. N., BA-JABER, A.S., SCHMIDT, G.R. and SMITH, G.C. 1995. Quality of extrusion cooked poultry meat products. Proceedings of the 8th Int. Conference: Recent Developments in Food Science and Nutrition , July 6-8, Cos, Greece. Food Flavors: Generation, Analysis and Process Influence, edited by G. Charalambous, Elsevier, New York, NY. pp. 1265-1280

SOFOS, J. N., BARBOSA, W.B., WEDERQUIST, H.J., SCHMIDT, G.R. and SMITH , G.C. 1995. Potential for growth and inhibition of Listeria monocytogenes in meat and poultry products. Proceedings of the 8th Int . Conference: Recent Developments in Food Science and Nutrition, July 6-8, Cos, Greece. Food Flavors:

Generation, Analysis and Process Influence, edited by G. Charalambous, Elsevier, New York, NY. pp. 1243-1264

SOFOS, J.N. 1995. Application of HACCP principles and beyond: Beef slaughter and fabrication. 82nd Annual Meeting of the International Association of Milk, Food and Environmental Sanitarians. July 30-August 2, Pittsburgh, PA. Abstract No. 25

SOFOS, J.N. 1995. Efforts to improve the microbiological status of meat in the United states after the 1993 E. coli O157:H7 outbreak. Joint Australian and New Zealand Institutes of Food Science and Technology Conference, May 15-19, Auckland, NZ. p. 35

SOFOS, J.N., HARMAYANI, E. and SMITH, G.C. 1995. Cholesterol: Health effects and potential for reduction. Nutrition Abstracts and Reviews (Series A) 65:533-539

SOFOS, J.N., SMITH, G.C., MORGAN, J.B. and SCHMIDT, G.R. 1995. Beef Slaughter and Fabrication HACCP Workshop Manual -- 1995. Colorado State University Center for Red Meat Safety. Technical Bulletin No. CRMS-9

WEDERQUIST, H.J., SOFOS, J.N. and SCHMIDT, G.R. 1995. Culture media comparison for the enumeration of Listeria monocytogenes in refrigerated vacuum packaged turkey bologna made with chemical additives. Lebensm.-Wissensch. und Technol. 28:455-461

WORFEL, R.C., SOFOS, J.N., SMITH, G.C., MORGAN, J.B. and SCHMIDT, G.R. 1995. Microbial contamination of condensates formed on superstructures of wood and other materials in meat plants. Dairy, Food and Environ. Sanit. 15:430-434

1996 CABEDO, L., J.N. SOFOS, and G.C. SMITH. 1996. Removal of bacteria from beef tissue by spray-washing after different times of exposure to fecal material. J. Food Prot. 59:--

CANNON, J.E., J.B. MORGAN, G.R. SCHMIDT, J.D. TATUM, J.N. SOFOS, G.C. SMITH, R.J. DELMORE and S.N. WILLIAMS. 1996. Growth and fresh meat quality characteristics of pigs supplemented with vitamin E. J. Anim. Sci. 74:98-105

GRAVES-DELMORE, L.R., G.C. SMITH, J.N. SOFOS, J.O. REAGAN, M.J. BUYCKE , and R. NICKELSON, II. 1996. Hot-water rinsing and trimming/washing of beef carcasses to reduce fecal and microbiological contamination. 56th Annual Meeting of the Institute of Food Technologists, June 22-26 , New Orleans, LA, Abstract No. 2GE-3

GRAVES-DEMORE, L.R., J.N. SOFOS, and G.C. SMITH. 1996. Hot-rinsing and trimming/washing decontamination of beef carcasses. CSU Beef Progress Report, pp. 95-100. --

HEATON, K.L., G.C. SMITH, J.N. SOFOS, M.J. AARONSON, and D.K. JONES. 1996. Analysis of pork products for chemical residues. J. Muscle Foods 7:213-224

KOCHEVAR, S., J. SOFOS, and G. SMITH. 1996. An evaluation of the effects of two beef carcass decontamination methods, 83rd Annual Meeting of the International Association of Milk, Food and Environmental Sanitarians, June 30-July 3, Seattle, WA, Abstract No. 124

KOCHEVAR, S.L. 1996. Steam-vacuuming and spray-washing as carcass decomtamination methods. M.S. Thesis, Animal Sciences, Colo State Univ ., Fort Collins, CO

KOCHEVAR, S.L., J.N. SOFOS, G.C. SMITH and R.R. BOLIN. 1996. Evaluation of steam-vacuuming as a pre-eviseration intervention to decontaminate beef carcasses. 56th Annual Meeting of the Institute of Food Technologists, June 22-26, New Orleans, LA, Abstract No. 2GE-1

KOCHEVAR, S.L., J.N. SOFOS, G.C. SMITH, and R.R. BOLIN. 1996. Decontamination of beef carcasses by use of steam-cleaning. CSU Beef Program Report, pp. 131-137

KOCHEVAR, S.L., J.N. SOFOS, S.B. LEVALLEY, and G.C. SMITH. 1996. The effect of water temperature, pressure and chemical solution on removal of fecal material and bacteria from lamb adipose tissues by spray-washing. 56th Annual Meeting of the Institute of Food Technologists, June 22-26, New Orleans, LA, Abstract No. 2GE-2

KUKAY, C.C., L.H. HOLCOOMB, J.N. SOFOS, J.B. MORGAN, J.D. TATUM, R.P. CLAYTON, and G.C. SMITH. 1996. Training of meat processors in small-scale and medium-scale plants in the application of HACCP. Dairy , Food, and Environ. Sanit. 16:74-80

REAGAN, J.O., et al. 1996. Trimming and washing of beef carcasses as a method of improving the microbiological quality of meat. J. Food Prot. 59:751-756

SCHNELL, T.D., J.N. SOFOS, V.G. LITTLEFIELD, J.B. MORGAN, B.M. GORMAN, R.P. CLAYTON and G.C. SMITH. 1996. Effects of dehairing on the microbial load and visual cleanliness of beef carcasses. CSU Beef Program Report, pp. 149-158

SCNHELL, T.D., G.C. SMITH, M.J. AARONSON, J.N. SOFOS, J.D. TATUM and J .B. MORGAN. 1996. Pesticide residues in beef from cattle fed fruits, vegetables, and/ or their by-products. CSU Beef Program Report, 159-166

SMITH, G.C., J.B. MORGAN, J.N. SOFOS, and J.D. TATUM. 1996. Supplemental vitamin E in beef cattle diets to improve shelf-life of beef. Animal Feed Sci. and Tech. 59:207-214

SOFOS, J.N. 1996. Rapid methods in meat microbiology. Distinguished Fellow Lecture at the 16th Annual Rapid Methods and Automation in Microbiology Workshop. Kansas State University, Manhattan, KS, July 11-19

VANSICKLE, J.L. and J.N. SOFOS. 1996. Evaluation of lactic and bacteria for the biological inhibition of Escherichia coli 0157:H7. 56th Annual Meeting of the Institute of Food Technologists, June 22-26 , New Orleans, LA, Abstract No. 35-7

WORFEL, R.C., J.N. SOFOS, G.C. SMITH, and G.R. SCHMIDT. 1996. Airborne bacterial contamination in beef slaughtering-dressing plants with different layouts. Dairy, Food, and Environ. Sanit. 16:440-443

1997 CABEDO, L., J.N. SOFOS, G.R. SCHMIDT, and G.C. SMITH. 1997. Attachment of Escherichia coli O157:H7 cells prepared in two substrates onto beef adipose and muscle tissues. J. Food. Prot. 60:102-106

CUTTING, J.H., J.A. HURLBUT and J.N. SOFOS. 1997. Quantitation of penicillin G in medicated premix feeds by micellar electrokinetic capillary chromatography J. AOAC Int. 80:951-955

GORMAN, B.M., S.L. KOCHEVAR, J.N. SOFOS, J.B. MORGAN, G.R. SCHMIDT, and G.C. SMITH. 1997. Changes on beef adipose tissue following decontamination with chemical solutions or water of 35C or 74C. J. Muscle Foods 8:185-197

GRAVES DELMORE, L.R., J.N. SOFOS, G.R. SCHMIDT and G.C. SMITH. 1997. Evaluation of multiple hurdles for beef carcass decontamination. Proceedings of the 50th Annual Reciprocal Meat Conference, American Meat Science Association, Chicago, IL

GRAVES DELMORE, L.R., J.N. SOFOS, G.R. SCHMIDT and G.C. SMITH. 1997. Development of a multiple hurdles model for reducing the probability of contamination of beef carcasses. CSU Beef Program Report, pp. 119-125

GRAVES DELMORE, L.R., J.N. SOFOS, G.R. SCHMIDT, and G.C. SMITH. 1997. Inactivation of pathogenic bacteria by the chemical dehairing process proposed for use on beef carcasses during slaughter. Proceedings of the 50th Annual Reciprocal Meat Conference, American Meat Science Association, Chicago, IL

GRAVES DELMORE,L.R., J.N. SOFOS, J.O. REAGAN, and G.C. SMITH. 1997. Hot-water rinsing and trimming/washing of beef carcasses to reduce physical and microbiological contamination. J. Food Sci. 62:373-376

KAIN, M.L., S.L. KOCHEVAR, J.N. SOFOS and G.C. SMITH. 1997. Detection and Control of External Pathogens Through Microbial Mapping: The New York Cull Dairy Cow Project. Final Report to the National Cattlemen's Beef Association. Dept. of Animal Sciences, Center for Red Meat Safety , Colorado State University, Fort Collins, CO. 46 pages

KOCHEVAR, S.L., J.N. SOFOS, G.C. SMITH and J.O. REAGAN. 1997. Extent of microbial contamination on beef carcasses during slaughtering and after 24 hours of chilling. IFT Book of Abstracts, page 131 (Abstract 46B-17)

KOCHEVAR, S.L., J.N. SOFOS, G.C. SMITH and J.O. REAGAN. 1997. Contamination of beef carcasses with Escherichia coli Biotype I in United States slaughtering plants. IFT Book of Abstracts, page 131 (Abstract 46B-19)

KOCHEVAR, S.L., J.N. SOFOS, R.R. BOLIN, J.O. REAGAN and G.C. SMITH. 1997. Steam-vacuuming as a pre-evisceration intervention to decontaminate beef carcasses. J. Food Prot. 60:107-113

KOCHEVAR, S.L., J.N. SOFOS, S.B. LEVALLEY, and G.C. SMITH. 1997. Effects of water temperature, pressure and chemical solution on removal of fecal material and bacteria from lamb adipose tissue by spray-washing. Meat Sci. 45:377-388

SCHMIEG, J., D.M. SPRAGUE and J.N. SOFOS. 1997. Detection of Shigella by PCR following filtration and minimal enrichment. Food and Drug Administration Forum on Regulatory Sciences, Bethesda, MD, Abstract No . A28

SCHNELL, T.D., J.N. SOFOS, J.B. MORGAN, M.J. AARONSON, J.D. TATUM, and G.C. SMITH. 1997. Pesticide residues in beef tissues from cattle fed fruits, vegetables, and other by-products. J. Muscle Foods 8:173-183

SMITH, G.C., K.L. HEATON, J.N. SOFOS, J.D. TATUM, M.J. AARONSON, and R .P. CLAYTON. 1997. Residues of antibiotics, hormones and pesticides in conventional, natural and organic beef. J. Muscle Foods 8:157-172

SOFOS, J.N. 1997. E. coli and Salmonella levels on beef carcasses - Survey results compared to mega-reg requirements. IAMFES Program and Abstract Book JFPRDR 60 (Sup. A), page 66 (Abstract S-11)

SOFOS, J.N. 1997. Evaluation of excised brisket, flank and rump samples for generic Escherichia coli contamination in beef slaughtering operations. Presented at a public meeting of the Food Safety and Inspection Service of the United States Department of Agriculture on Microbial Testing as part of the United States Meat and Poultry Inspection Regulations. May 8, Washington, D.C

SOFOS, J.N. 1997. Mapping of microbial contamination in beef slaughtering operations. Presented to personnel of the Food Safety and Inspection Service of the United States Department of Agriculture. February 27, Washington, D.C

SOFOS, J.N. 1997. Needs and concerns for microbial inactivation in foods. Presented at the annual meeting of the Institute of Food Technologists, June 14-18, Orlando, FL. IFT Book of Abstracts, page 5 (Abstract 2-1

SOFOS, J.N. 1997. Non-acid meat decontamination technologies: Model studies and commercial applications. Presented at the World Congress on Food Hygiene of the World Association of Veterinary Food Hygienists . August 24-29, The Hague, The Netherlands

SOFOS, J.N. 1997. Rapid methods: Their use in the field and applications to state public health laboratories. Presented at the 40th Annual Planning Conference of the Association of State and Territorial Public Health Laboratory Directors, June 2, San Diego, CA

SOFOS, J.N. and G.C. SMITH. 1997. Meat decontamination technologies: Model studies and commercial applications. Proceedings of the World Congress on Food Hygiene (The Hague, The Netherlands) page 269

SOFOS, J.N., S.L. KOCHEVAR, G.C. SMITH, J.O. REAGAN, D.D. HANCOCK, S.C . INGHAM, G.R. LUNDELL and J.B. MORGAN. 1997. Incidence of Salmonella on beef carcasses at various stages of the slaughtering process. IAMFES Program and Abstract Book JFPRDR 60 (Sup. A), page 51 (Abstract P71)

SOFOS, J.N., S.L. KOCHEVAR, G.C. SMITH, J.O. REAGAN, D.R. BUEGE, D.D. HANCOCK, G.R. LUNDELL and J.B. MORGAN. 1997. Probabilities of passing E. coli performance criteria in seven beef slaughering plants. IAMFES Program and Abstract Book JFPRDR 60 (Sup. A), page 51 (Abstract P72

SOFOS, J.N., S.L. KOCHEVAR, K.E. BELK, R.C. CANNELL, M.L. KAIN and G.C . SMITH. 1997. Mapping of Microbial Contamination of Beef Slaughtering Operations. Final Report to the National Cattlemen's Beef Association. Dept. of Animal Sciences, Center for Red Meat Safety, Colorado State University, Fort Collins, CO. 97 pages

ZERBY, H.N. 1997. Effects of dietary vitamin E supplementation on display-life of fresh beef. M.S. Thesis, Meat Science Program, Department of Animal Sciences, Colorado State University, Fort Collins , CO

ZERBY, H.N., K.E. BELK, J.N. SOFOS, G.C. SMITH and L.R. MCDOWELL. 1997 . Effects of vitamin E supplementation and high versus low initial microbial loads on retail display life of beef muscle. IAMFES Program and Abstract Book JFPRDR 60(Sup. A), page 41 (Abstract P35)

1998 Cabedo, L., Sofos, J.N. and Smith, G.C. 1998. Bacterial growth in ground beef patties made from animals fed diets without or with supplemental vitamin E. J. Food Prot. 61:36-40

Cabedo, L., Sofos, J.N., Schmidt, G.R. and Smith, G.C. 1998. Changes in bacterial counts of vacuum-packaged beef from animals fed high Vitamin E. Proc. International Congress of Meat Science and Technology (Barcelona, Spain) 44:322-323

Cabedo, L., Sofos, J.N.,Schmidt, G.R. and Smith, G.C. 1998. Changes in Listeria monocytogenes populations in raw and cooked beef, pork, lamb and chicken meat. Proc. International Congress of Meat Science and Technology (Barcelona, Spain) 44:330-331

Delmore, R. J, Jr. 1998. Microbiological profile and decontamination for beef variety meats. Ph. D. Dissertation, Department of Animal Sciences, Colorado State University, Fort Collins, Colorado

Delmore, R. J., Jr., Sofos,J.N., Schmidt, G.R., Belk, K.E. and Smith, G.C. 1998. Reduction in microbiological contamination of beef variety meats exposed to various decontamination treatments. IAMFES Annual Meeting, Program & Abstract Book. JFPRDR 61(Sup. A):62 (Abstract P62

Delmore, R. J., Jr., Zerby, H.N., Sofos, J.N., Schmidt, G.R., Belk, K .E. and Smith, G.C. 1998. Development of a Microbial Profile and Identification of Microbiological Intervention Strategies for Beef Variety Meats. Final Report to U.S. Meat Export Federation, 148 pages

Delmore, R. J., Schmidt, G.R., Tatum, J.D., Sofos, J.N. and Smith, G.C . 1998. Supplementation of vitamin E to bovine females in 'white cow', mature beef, upgrading programs. J. Muscle Foods 9:153-171

Delmore, R. J., Sofos, J.N., Schmidt, G.R., Belk, K.E. and Smith, G.C. 1998. Bacterial counts and incidence of Salmonella spp., Listeria monocytogenes, and Escherichia coli O157:H7 detected on U.S. beef variety meats. J. Anim. Sci. 76(Suppl. 1):154 (Abstract 595)

Garcia, G. R., Ramirez, C., Hunt, J., Madzo, S.C. and Sofos, J.N. 1998 . Detection of inactivated Brucella abortus and Brucella melitensis in goat cheese by direct DNA amplification. FDA Science Forum, Biotechnology: Advances, Applications and Regulatory Challenges, December 8-9, Washington, DC. Abstract K19

Genigeorgis, C. and Sofos, J.N. 1998. Inactivating human pathogens by processing and packing. In: Veterinary Aspects of Meat Production, Processing, and Inspection. University of Utrecht, The Netherlands. pp . 1-23

Graves Delmore, L. R. 1998. Evaluation of multiple decontamination treatments on beef carcass tissue. Ph. D. Dissertation, Department of Animal Sciences, Colorado State University, Fort Collins, Colorado

Graves Delmore, L. R., Sofos, J.N., Schmidt, G.R. and Smith, G.C. 1998 . Decontamination of inoculated beef with sequential spraying treatments. J. Food Sci. 63:890-893

Hagen, C. J., Singleton, E.R., Kreuzer, K.S., Sloan, E.M. and Sofos, J .N. 1998. Isolation of catalase-negative Listeria monocytogenes from foods. Dairy, Food and Environmental Sanitation 18:424-426

Kain, M. L., Kochevar, S.L., Sofos, J.N., Belk, K.E., Rossiter, C., Reagan, J.O. and Smith, G.C. 1998. Condition and cleanliness of live animals in relation to microbiological counts on cow carcasses. J. Anim. Sci. 76(Suppl. 1):142 (Abstract 548)

Kain, M. L., Kochevar, S.L., Sofos, J.N.,Rossiter, C., Belk,K.E. and Smith, G.C. 1998. Live animal characteristics and carcass contamination in cull dairy cows. CSU Beef Program Report, pp. 37-41

Kain, M. L., Sofos, J.N. and Smith, G.C. 1998. Recovery of E. coli pure culture suspensions from sponges following shaking or stomaching. IAMFES Annual Meeting, Program & Abstract Book. JFPRDR 61(Sup. A):62 (Abstract P90)

Kain, M. L., Sofos, J.N., Belk, K.E. and Smith, G.C. 1998. Time and temperature effects on bacterial numbers detected on sponges used to sample beef carcass tissue. Institute of Food Technologists, Annual Meeting Technical Program. Abstract Number 9-16, page 15

Kain, M. L., Sofos, J.N., Zerby, H.N., Belk, K.E., Hardin, M.D. and Smith, G.C. 1998. Shipping, storage and sampling-sponge effects on bacterial numbers detected from pork carcass skin and fat surfaces. IAMFES Annual Meeting, Program & Abstract Book. JFPRDR 61(Sup. A):62 (Abstract P89

Kain, M. L., Ware, L.M.,Zerby, H.N., Cannell, R.C., Belk, K.E., Sofos, J.N. and Smith, G.C. 1998. Pilot Study for the National Study Microbial Mapping II. Final Report to National Cattlemen's Beef Association, 12 pages

Schmidt, G. R., Sofos, J.N. and Smith, G.C. 1998. How to keep the hot box clean. Meat Processing Magazine, February, pp. 34, 37, 38

Smith, G. C., Cannell, R.C., Belk, K.E., Tatum, J.D., Sofos, J.N. and Schmidt, G.R. 1998.Beef Quality Assurance Audits: Incidence of Injection-Site Damage in Top Sirloin Butts and in Muscles of the Round-1997. Final Report to National Cattlemen's Beef Association, 11 pages

Smith, G. C., Cannell, R.C., Kain, M.L., Belk, K.E., Tatum, J.D., Sofos, J.N. and Schmidt, G.R. 1998. Beef Quality Assurance Audits: Assays for Prevalence of Antibiotics in Injection-Site Legions From Muscles in Top Sirloin Butts and in Rounds. Final Report to National Cattlemen's Beef Association, 13 pages

Smith, G. C., Sofos, J.N. and Belk. K.E. 1998. Interventions From The Farm Or Feedlot To The Food Store: Minimizing Microbiological Food Safety Risks. Proceedings Alltech's Fourteenth Annual Symposium (Lexington, KY) pp. 323-350

Smith, G. C., Williams, S.N., Sofos, J.N., Belk, K.E. and Tatum, J.D. 1998. Supplementation of cattle diets with Vitamin D3 to improve beef tenderness or with Vitamin E to improve beef color and caselife. Proceedings Meat Industry Research Conference (Philadelphia, PA) pp. 1-15

Sofos, J. N. 1998. Carcass intervention/decontamination technologies. Proc. of Technical Symposium on Intervention Technologies and Biotechnology for the Canadian Meat Industry. Sponsored by Canadian Meat Research Institute and Canadian Meat Science Association, February 4, Banff, Alberta, Canada. pp. 1-17

Sofos, J. N. 1998. Carcass Intervention/Decontamination Technologies. Ontario Cattlemen's Association Newsletter

Sofos, J. N. 1998. Carcass sampling techniques/Testing methods/Baseline levels of contamination. Presented at University of Western Sydney Hawkesbury, Richmond, NSW, Australia, April 23

Sofos, J. N. 1998. Decontamination Intervention Technologies. Keynote presentation at the Technology Symposium organized by the Canadian Meat Council, Canadian Meat Science Association, and Canadian Meat Research Institute. February 4, Banff, Alberta, Canada

Sofos, J. N. 1998. Food Safety Issues. Presented at University of Western Sydney, Hawkesbury,Richmond, NSW, Australia, April 24

Sofos, J. N. 1998. Food Safety Issues. Presented at the Colorado State University Department of Animal Sciences seminar, February 2, Fort Collins, CO

Sofos, J. N. 1998. Food Safety-The Real Facts. Presented at the meeting of the Colorado State University Chapter of Gamma Sigma Delta, January 19, Fort Collins, CO

Sofos, J. N. 1998. HACCP Update. Presented at University of Western Sydney, Hawkesbury, Richmond, NSW, Australia, April 23

Sofos, J. N. 1998. Hurdling; Evaluating red meat pathogen reduction technologies. Meat & Poultry (April), pp. 18-21

Sofos, J. N. 1998. Potential interactions between antioxidants and microbial meat quality. Proc. Dietary Strategies for Improving Muscle-Based Food Products (Madrid, Spain) pp. 29-30

Sofos, J. N. and Smith, G.C. 1998. Evaluation of various treatments to reduce contamination on carcass tissue. Proc. International Congress of Meat Science and Technology (Barcelona, Spain) 44:316-317

Sofos, J. N. and Smith, G.C. 1998. Nonacid meat decontamination technologies: Model studies and commercial applications. Int. J. Food Microbiol. 44(3):171-189

Sofos, J. N., Belk, K.E. and Smith, G.C. 1998. Minimizing microbiological food safety risks: Potential for preslaughter (preharvest) interventions. A developing white paper prepared for the Beef Quality Assurance Advisory Board of the National Cattlemen's Beef Association, 88 pages

Sofos, J. N., Beuchat, L.R., Davidson, P.M. and Johnson, E.A. 1998. Naturally Occurring Antimicrobials in Food. Council of Agricultural Science and Technology, Ames, IA

Sofos, J. N., Kain, M.L., Belk, K.E. and Smith, G.C. 1998. Microbial Mapping II: Determining microbiological counts on beef carcasses, wholesale and retail cuts, to assist those in fabrication distribution and retailing sectors to deliver safe beef to retail customers. Final Report to National Cattlemen's Beef Association, 29 pages

Sofos, J. N., Kain, M.L., Kochevar, S.L., Belk, K.E., Cannell, R.C., Smith, G.C., Buege, D.R., Ingham, S.C., Hancock, D.D., Morgan, J.B., Bellinger, G.R. and Reagan, J.O. 1998. Microbial mapping of beef carcasses during slaughter-Phase I. CSU Beef Program Report, pp. 17-23

Ware, L. M. 1998. A comparison of sponging and excising as sampling procedures for beef carcass tissue and the influence of handling and storage on the microbial status of beef. M. S. Thesis, Department of Animal Sciences, Colorado State University, Fort Collins, Colorado

Ware, L. M., Kain, M., Sofos, J.N., Belk, K.E. and Smith, G.C. 1998. A comparative evaluation of sponging and excising as sampling procedures for microbiological analysis of beef carcass tissue. IAMFES Annual Meeting, Program & Abstract Book. JFPRDR 61(Sup. A):61 (Abstract P88)

Ware, L. M., Kain, M.L., Sofos, J.N., Belk, K.E. and Smith, G.C. 1998. Influence of sampling procedure and stage of sampling on the microbiological status of fresh beef. J. Anim. Sci. 76(Suppl. 1):142 (Abstract 547)

Zerby, H. N., Belk, K.E., Sofos, J.N. and Smith, G.C. 1998. Microbiological sampling of hog carcasses. Proc. Pork Quality & Safety Summit, pp. 77-85, July 14-15, National Pork Producers Council, Des Moines, IA

Zerby, H. N., Belk, K.E., Sofos, J.N., McDowell, L.R., Williams, S.N. and Smith, G.C. 1998. Effects of Vitamin E and initial microbiological counts on beef caselife. Proc. International Congress of Meat Science and Technology (Barcelona, Spain) 44:490-491

Zerby, H. N., Belk, K.E., Sofos, J.N., McDowell, L.R.,Williams, S.N. and Smith, G.C. 1998. Effects of initial microbiological contamination level on appearance and retail caselife of fresh beef steaks derived from cattle fed diets with different levels of Vitamin E. CSU Beef Program Report, pp. 1-8

Zerby, H. N., Belk, K.E., Sofos, J.N., McDowell, L.R., Williams, S.N. and Smith, G.C. 1998. Caselife of seven retail beef products from the carcasses of beef cattle supplemented with alpha-tocopoheryl acetate. CSU Beef Program Report, pp. 9-15.

Zerby, H. N., Belk, K.E., Sofos,J.N., Schmidt, G.R. and Smith, G.C. 1998. Microbiological sampling of hog carcasses. Final Report to National Pork Producers Council, 51 pages

Zerby, H. N., Delmore,R.J., Belk, K.E., Sofos, J.N. and Smith. G.C. 1998. Intervention strategies for pork variety meats. Proc. Pork Quality & Safety Summit, pp. 87-99, July 14-15, National Pork Producers Council, Des Moines, IA

Zerby, H. N., Delmore,R.J., Jr., Murphree, R., Belk, K.E. Sofos, J.N., Schmidt, G.R., Bellinger, G.L., Pape, A., Hardin, M., Lloyd, W. and Smith, G.C. 1998. Development of a microbiological profile of pork variety meats and intervention strategies for reducing microbiological contamination on pork variety meats. Final Report to U.S. Meat Export Federation, 113 pages

1999 Bacon, R.T., Sofos, J.N., Belk, K.E., Reagan, J.O., and Smith, G.C. 1999. Commercial evaluation of multiple-sequential interventions for decontamination of beef carcasses. IAMFES 86th Annual Meeting. Abstract T-3

Chuanchuen, R. 1999. Foodborne Significance of Multi-Drug Resistant Salmonella Typhimurium DT104: An Overview. M.S. Paper, Colorado State University, Fort Collins

Clark, S.B., Hurlbut, J.A., and Sofos, J.N. 1999. Sensitivity of detection of various veterinary drugs using the fast antimicrobial screen test (FAST). Food and Drug Administration Laboratory Information Bulletin, 7 pages

Clark, S.B., Klessling, C.R., Hurlbut, J.A., Sofos , J.N., and Madson, M.R. 1999. Sensitivity of detection of various veterinary drugs using the fast antimicrobial screen test 113. AOAC Int. Meeting, Houston, TX , September 26-30. Abstract No. H-1403

Delmore, Jr., R.J., J.N. Sofos, J.N., Belk, K.E., Lloyd, W.R., Bellinger, G.L.,Schmidt, G.R., and Smith, G.C. 1999. Good manufacturing practices for improving the microbiological quality of beef variety meats. Dairy, Food and Environ. Sanit. 19:14-24

Garcia, G.R., Sloan, E., Ramirez, C., Ramsey, S.M., and Sofos, J.N. 1999. A preliminary evaluation of two chromogenic agar media for detection of Escherichia coli O157:H7. Food and Drug Administration Laboratory Information Bulletin, 14 pages

Kain, M., Sofos, J.N., Belk, K.E., Reagan, J.O., Smith, G.C., Buege, D .R., Henning, W.P., Morgan, J.B., Ringkob, T.P.,and Bellinger G.R. 1999. Microbiological contamination baselines of beef carcasses, wholesale cuts and retail cuts. IAMFES 86th Annual Meeting. Abstract P44

Schmidt, G.R., Sofos, J.N., Duffy, E.A., Belk, K.E., and Smith, G.C. 1999. HACCP training at Colorado State University. Proc. Reciprocal Meat Conference. 52:133 (Abstract)

Sofos, J.N. 1999. Strategies to Control Stressed Pathogens and Provide Safe Foods. Annual Meeting of the Institute of Food Technologists. July 24-28, Chicago, IL

Sofos, J.N. and Busta, F.F. 1999. Chemical Food Preservatives. Chapter 17, In Principles and Practice of Disinfection, Preservation and Sterilization, third edition, A.D. Russell, W.B. Hugo and G.A.J. Ayliffe (editors). Blackwell Science Ltd., Oxford, UK. pp. 485-541

Sofos, J.N., and Smith, G.C. 1999. The role of slaughter hygiene in food safety. Chapter in EOLSS Encyclopedia of Life Support Systems, EOLSS Publishers Co. Ltd., Oxford, U.K

Sofos, J.N., Belk, K.E., and Smith G.C. 1999. Processes to reduce contamination with pathogenic microorganisms in meat. Proceedings of the International Congress of Meat Science and Technology (Yokohama, Japan) 45(2):596-605

Sofos, J.N., Beuchat, L.R., Davidson, P.M., and Johnson, E.A. 1999. Naturally occurring antimicrobials in food: Interpretive Summary. Regulatory Toxicology and Pharmacology 28:71-72

Sofos, J.N., Kochevar, S.L., Bellinger, G.R., Buege, D.R., Hancock, D .D., Ingham, S.C., Morgan, J.B., Reagan, J.O., and Smith, G.C. 1999. Sources and extent of microbiological contamination of beef carcasses in seven United States slaughtering plants. J. Food Prot. 62:140-145

Sofos, J.N., Kochevar, S.L., Reagan, J.O., and Smith, G.C. 1999. Extent of beef carcass contamination with Escherichia coli and probabilities of passing U.S. regulatory criteria. J. Food Prot. 62:234-238

Sofos, J.N., Kochever, S.L., Reagan, J.O., and Smith, G.C. 1999. Incidence of Salmonella on beef carcasses relating to U.S. Meat and Poultry Inspection Regulations. J. Food Prot. 62:467-473

Ware, L.M., Kain, M.L., Sofos, J.N., Belk, K.E., and Smith, G.C. 1999. Comparison of sponging and excising as sampling procedures for microbiological analysis of fresh beef carcass tissue. J. Food Prot. 62:1255-1259

Zerby, H.N., Belk, K.E., Ahola, J.K., Sofos, J.N., Schaefer, D.M., Morgan, J.B., and Smith, G.C. 1999. Effects of muscle a-tocopherol level and surface microbiological contamination on retail caselife of fresh beef from the U.S., Japan and Australia. Meat Sci. 52:111-118

Zerby, H.N., Belk, K.E., Hardin, M., Lloyd, W., Sofos , J.N., and Smith, G.C. 1999. Extent of microbiological contamination on pork variety meats. IAMFES 86th Annual Meeting. Abstract T-12

Zerby, H.N., Belk, K.E., Hardin, M., Lloyd, W., Sofos, J.N., and G.C. Smith, G.C. 1999. Application of treatments to reduce contamination of pork variety meats. IAMFES 86th Annual Meeting. Abstract T-17

Zerby, H.N., Belk, K.E., Sofos, J.N., McDowell , L.R., and Smith, G.C. 1999. Case life of seven retail products from beef cattle supplemented with alpha-tocopheryl acetate. J. Anim. Sci. 77:2458-2463

Zerby, H.N., Belk, K.E., Sofos, J.N., McDowell, L.R., Williams, S.N., and Smith, G.C. 1999. Display life of fresh beef containing different levels of vitamin E and initial microbiological contamination. J. Muscle Foods 10:345-355

Zerby, H.N., Belk, K.E., Sofos, J.N., Schmidt, G.R., Kotrola, N., and Smith, G.C. 1999. Efficacy of acidified sodium chlorite as a decontamination treatment for pork tongues. American Society of Animal Science, Annual Meeting. Abstract 43-6

Zerby, H.N., Belk,K. E., Hardin, M., Sofos, J.N., and Smith, G.C. 1999 . Levels of microbiological contamination of pork carcasses during slaughter. IAMFES 86th Annual Meeting. Abstract T-11

2000 Albright, S.N., Avens, J.S., Morton, A.S., Prewitt, B.E., Kendall, P.A . and Sofos, J.N. 2000. Destruction of bacteria on chicken carcasses by steam and boiling water immersion. Food Safety Objectives Ceres Forum, Organized by Food Control and Georgetown Center for Food and Nutrition Policy, Dec. 4-5, Washington, D.C. Abstract No. 33.

Bacon, R.T., Belk, K.E., Sofos, J.N. and Smith, G.C. 2000. Antimicrobial resistance of Salmonella spp. isolates found on beef animal hides and carcasses and the potential ramifications for producers. Reciprocal Meat Conference, June 18-21, Ohio State University, Columbus, OH, Abstract, 53:117.

Bacon, R.T., Belk, K.E., Sofos, J.N. and Smith, G.C. 2000. Incidence of Escherichia coli O157:H7 on hide, carcass and beef trimming samples collected from United States packing plants. Proc. Reciprocal Meat Conference, Ohio State University, Columbus, OH, 53:106-108.

Bacon, R.T., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. A comparison of the three commercial beef carcass decontamination systems. Animal Sciences Research Report 2000. p. 45-51. Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Bacon, R.T., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. Incidence and antibiotic resistance of Salmonellae spp. Cultures isolated from animal hide and beef carcasses. Annual Meeting of the International Association for Food Protection, August 6-9, Atlanta, GA, Abstract P099, p. 71.

Bacon, R.T., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. Incidence of Salmonella spp. on beef cattle hides and carcasses in eight commercial beef slaughtering facilities. Animal Sciences Research Report 2000, p. 53-56. Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Bacon, R.T., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. Post-chilling application of a commercial steam vacuum unit to fresh beef adipose tissue inoculated with Salmonella spp. Animal Sciences Research Report 2000. p. 35-39, Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Bacon, R.T., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. Evaluation of Zero Tolerance final rail inspection conducted in commercial beef processing facilities. Animal Sciences Research Report 2000, p. 41-44. Department of Animal Sciences, Colorado State University, Fort Collins , CO.

Bacon, R.T., Sofos, J.N., Belk, K.E., Mirtsching, W.M., Clayton, R.P., Reagan, J.O. and Smith, G.C. 2000. Microbial populations on animal hides and beef carcasses at different stages of slaughter in plants employing multiple-sequential interventions for decontamination. J. Food Prot. 63:1080-1086.

Belk, K.E., Segomelo, K., Kain, M.L, Bellinger, G.R., Scanga, J.A., Sofos, J.N. and Smith, G.C. 2000. Growth of pathogens on fresh pork chops and ground pork after encountering temperature abuse. Proc. Pork Quality and Safety Summit, Des Moins, IA, p. 294-301.

Delmore, Jr., R.J., Sofos, J.N., Schmidt, G.R., Belk, K.E., Lloyd, W.R . and Smith, G.C. 2000. Interventions to reduce microbiological contamination of beef variety meats. J. Food Prot. 63:44-50.

Duffy, E.A., Belk, K.E., Sofos, J.N., Bellinger, G.R. and Smith, G.C. 2000. United States retail pork microbiological baseline. Proc. Pork Quality and Safety Summit, Des Moines, IA p. 305-309.

Duffy, E.A., Belk, K.E., Sofos, J.N., Bellinger, G.R., Pape, A. and Smith, G.C. 2000. Levels of microbial contamination in the United States pork retain products. Animal Sciences Research Report 2000. p. 23-27. Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Duffy, E.A., Bellinger, G.R. Page, A., Belk, K.E., Sofos, J.N. and Smith, G.C. 2000. Levels of microbial contamination in the United States pork retail products. Annual Meeting of the International Association for Food Protection, August 6-9, Atlanta, GA, Abstract P099, 87:71.

Duffy, E.A., LeValley, S.B., Belk, K.E., Sofos, J.N., and Smith, G.C. 2000. Pre-harvest management practices, good manufacturing practices during harvest, and microbiological quality of lamb carcasses. Dairy, Food & Environ. Sanit. 20:753-762.

Duffy, E.A., LeValley, S.B., Kain, M.L., Belk, K.E., Sofos, J.N., Tatum, J.D., Smith, G.C. and Kimberling, C.V. 2000. Microbial contamination occurring on lamb carcasses processed in the United States. Annual Meeting of the International Association for Food Protection, August 6-9, Atlanta GA, Abstract P100, 87:72.

Duffy, Elizabeth A. 2000. Influence of pre-harvest management practices on microbial contamination of lamb carcasses and baseline levels of microbial contamination on United States lamb carcasses and pork retail products, M.S. Thesis, Dept. of An. Sci., Colo. State Univ ., Fort Collins, CO.

Garcia, G., Sloan, E., Ramirez, C., Ramsey, S.M. and Sofos, J.N. 2000. A preliminary evaluation of two chromogenic agar media for detection of enterohemorrhagic Escherichia coli. Presented at the 2000 FDA Science Forum - FDA and the Science of Safety: New Perspectives, Feb. 14-15, Washington, D.C., Abstract J11, p. 72.

Ramirez, C., Sofos, J. and Singleton, E. 2000. Sensitivity of a polymerase chain reaction (PCR) method for the detection of Shigella species inoculated in produce rinses. Food and Drug Administration, Laboratory Information Bulletin 4204, 17 pages.

Ramirez, C., Sofos, J.N. and Singleton, E.R. 2000. Sensitivity of a direct polymerase chain reaction (PCR) method for Shigella species inoculated in produce rinses. Presented at the 2000 FDA Science Forum - FDA and the Science of Safety: New Perspectives, Feb. 14-15, Washington, D.C., Abstract J19, p. 74.

Samelis, J., Strohecker, K., Sofos, J.N., Belk, K.E., Scanga, J.A. and Smith, G.C. 2000. Screening of antimicrobials against Listeria monocytogenes in pork bologna. Proc. Intl. Congress of Meat Sci. and Tech., Buenos Aires, Argentina, p. 660-661.

Scanga, J.A., Grona, A.D., Belk, K.E., Sofos, J.N., Bellinger, G.R. and Smith, G.C. 2000. Microbiological contamination of raw beef trimmings and ground products. Meat Sci. 56:145-152.

Scanga, J.A., Samelis, J., Strohecker, K., Sofos, J.N., Belk, K.E. and Smith, G.C. 2000. Screening of antimicrobials against Listeria monocytogenes in pork bologna. Proc. Pork Quality and Safety Summit, Des Moines, IA, p. 189-193.

Segomelo K., Kain, M.L., Bellinger, G., Belk, K.E., Scanga, J., Sofos, J.N. and Smith, G.C. 2000. Population changes of pathogenic bacteria inoculated in fresh pork following chilled storage and simulated consumer temperature abuse. Annual Meeting of the International Association for Food Protection, August 6-9, Atlanta, GA. Abstract P097, 87:71.

Segomelo, K., Kain, M.L, Belk, K.E., Bellinger, G.R., Scanga, J.A., Sofos, J.N. and Smith, G.C. 2000. Bacteria pathogen changes in fresh pork after storage and consumer abuse. Proc. Intl. Congress of Meat Sci. and Tech., Buenos Aires, Argentina, p. 728-729.

Segomelo, K., Kain, M.L, Belk, K.E., Bellinger, G.R., Scanga, J.A., Sofos, J.N. and Smith, G.C. 2000. Pathogenic bacteria populations in inoculated fresh pork after chilled storage and simulated consumer abuse. Animal Sciences Research Report, p. 61-65. Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Segomelo, K., Kain, M.L, Belk, K.E., Bellinger, G.R., Scanga, J.A., Sofos, J.N. and Smith, G.C. 2000. Changes in pathogenic bacteria counts during limited abuse of fresh pork. Proc. Intl. Congress of Meat Sci. and Tech., Buenos Aires, Argentina, p. 730-731.

Segomelo, K., Kain, M.L, Belk, K.E., Bellinger, G.R., Scanga, J.A., Sofos, J.N. and Smith, G.C. 2000. Change sin inoculated bacterial pathogens on fresh pork stored at

temperatures to simulate mild distribution abuse. Animal Sciences Research Report p. 57-59. Department of Animal Sciences, Colorado State University, Fort Collins , CO.

Segomelo, K., Kain, M.L, Bellinger, G., Belk, K.E., Scanga, J., Sofos, J.N. and Smith, G.C. 2000. Fate of bacterial pathogens inoculated on fresh pork during simulated temperature abuse at distribution. Annual Meeting of the International Association for Food Protection, August 6-9, Atlanta, GA, Abstract P068, 87:60.

Segomelo, Keolebogile. 2000 Changes in population of bacteria inoculated on fresh pork and subjected to limited temperature abuse, M .S. Thesis, Dept. of Food Sci. and Human Nutrn, Colo. State Univ., Fort Collins, CO.

Sloan, E., O'Neill, M, Kaysner, C., DePaola, A. and Sofos, J. 2000. Comparison of two nonradioactive gene probes for the enumeration of Vibrio parahaemolyticus in crabmeat. Food and Drug Administration, Laboratory Information Bulletin 4221, 19 pages.

Smith, G.C., Belk, K.E., Sofos, J.N., Tatum, J.D. and Williams, S.N. 2000. High E beef: The Science and Technology. Proceedings of the Canadian Beef Summit (Las Vegas, NV) pp. 21-51.

Smith, G.C., Sofos, J.N., Belk, K.E. Scanga, J.A. and Tatum, J.D. 2000 . Traceback, Traceability and Source Verification in the U.S. Beef Industry. XXI World Buiatrics Congress, Punta del Este, Uruguay (Abstract).

Smith, G.C., Sofos, J.N., Belk, K.E., Scanga, J.A. and Tatum, J.D. 2000. Safety of food of ruminant origin. XXI World buiatrics Congress, Punta del Este, Uruguay (Abstract).

Smith, G.C., Sofos, J.N., Belk, K.E., Scanga, J.A. and Tatum, J.D. 2000. Pathogen Contamination of Cattle and Beef; Challenges and Opportunities in Process Control. XXI World Buiatrics Congress, Punta del Este, Uruguay (Abstract).

Smith, G.C., Sofos, J.N., Belk, K.E., Scanga, J.A. and Tatum, J.D. 2000. Quality of Beef and its Certification for the Public in the Future. XXI World Buiatrics Congress, Punta del Este, Uruguay (Abstract).

Sofos, J.N. 2000. Approaches to pre-harvest food safety assurance. Proceedings of Euroconference: Food Safety Assurance and Veterinary Public Health; The Topical Research Issues - Event 1: Food Safety Assurance in the Pre-harvest, University of Veterinary Medicine Vienna , Austria, p. 13-14.

Sofos, J.N. 2000. Sorbic Acid. In Natural Food Antimicrobial Systems, A.S. Naidu, editor. CRC Press, Inc. Boca Raton, FL. P. 637-659.

Sofos, J.N., Belk, K.E., Rossiter, C., Reagan, J.O. and Smith, G.C. 2000. Live dairy cull cow characteristics and associated microbial contamination. Proceedings of Euroconference: Food Safety Assurance and Veterinary Public Health: The Topical

Research Issues - Event 1: Food Safety Assurance in the Pre-harvest Phase, University of Veterinary Medicine Vienna, Austria, p. 123-124.

Twohy, C.W., Hoffman, C.A., Zuroski, K.E., Bell, J. Ellis and Sofos, J .N. 2000. A robotics workstation for testing of liquid sporicidal agents. Food and Drug Administration, Laboratory Information Bulletin 4223, 10 pages.

2001 Bacon, R.T., Sofos, J.N., Belk, K.E., and Smith, G.C. 2001. Microbial mapping III. Determining microbiological counts on beef subprimal cuts during/ following fabrication with and without microbiological decontamination treatments. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 105-110.

Bedie, G. K. 2001. Effects of antimicrobials in the formulation and post packaging thermal treatment to control Listeria monocytogenes in post-processing inoculated frankfurters. MS Thesis. Colorado State University, Fort Collins, CO.

Bedie, G., J. Samelis, J., Sofos, J.N., Belk, K.E., Scanga, J.A., and Smith, G.C. 2001. Effect of antimicrobials in the formulation and post-packaging thermal pasteurization on Listeria monocytogenes inoculated on frankfurters after peeling. IAFP Annual Meeting, Minneapolis, Minnesota, August 5-8. (Abstract PO46).

Bedie, G.K., Kain, M.L., Samelis, J., Sofos, J.N., Belk, K.E., Scanga, J.A., and Smith, G.C. 2001. Evaluation of antimicrobials incorporated into the formulation against post-processing contamination of Listeria monocytogenes on frankfurters stored at 4 degrees C in vacuum packages . Animal Sciences Research Report, CSU, Fort Collins. pp. 65-67.

Bedie, G.K., Samelis, J., Sofos, J.N., Belk, K.E., Scanga, J.A., and Smith, G.C. 2001. Antimicrobials in the formulation to control post-processing contamination by Listeria monocytogenes on frankfurters stored at 4 degrees C in vacuum. IFT Annual Meeting, New Orleans, Louisiana, June 23-26. (Abstract 59E-5).

Clark, S.B. S.B. Turnipseed, S.B., G.J. Nandrea, G.J., M.R. Madson, M .R., J.N. Sofos, J.A. Hurlbut and C.E. Shultz. 2001. Identification and confirmation of flumixin meglumine and phenylbutazone residues in animal kidney by ELISA screening and LC/ MS. 115th AOAC Int. Annual Meeting, September 9-13, 2001, Kansas City MO. Abstract A-101.

Clark, S.B., Kiessling, C.R., Madson, M.A., Hurlbut, J.A., and Sofos, J.N. 2001. Stability and sensitivity of detection of various veterinary drugs using the fast antimicrobial screen test (FAST). Food and Drug Administration, Laboratory Information Bulletin 4238, 13 pages.

Clark, S.B., Turnipseed, S.B., Nandrea, G.J., Hurlbut, J.A., Sofos, J .N., and Shultz, C.E. 2001. Identification and confirmation of flumoxin megulmine and phenylbutazone residues in animal kidney by ELISA screening and liquid chromatography mass spectrometry. FDA Science Forum, Washington, DC.

Clark, S.B., Turnipseed, S.B., Nandrea, G.J., Madson, M.R., Singleton, E.R., Hurlbut, J.A., Sofos, J.N., and Schultz, C.E. 2001. Identification and confirmation of flunixin meglumine and phenylbutazone residues in animal kidney by ELISA screening and liquid chromatography mass spectrometry. Food and Drug Administration, Laboratory Information Bulletin 4246, 12 pages.

Duffy, E.A., Belk, K.E., Sofos, J.N., Bellinger, G.R., Pape, A.and Smith, G.C. 2001. Extent of Microbial Contamination in United States Pork Retail Products. J. Food Prot. 64:172-178.

Duffy, E.A., Belk, K.E., Sofos, J.N., LeValley, S.B., Kain, M.L., Tatum, J.D., Smith, G.C., and Kimberling, C.V. 2001. Microbial Contamination Occurring on Lamb Carcasses Processed in the United States. J. Food Prot. 64:503-508.

Ikeda, J.S., Samelis, J., Kendall, P.A., Smith, G.C., and Sofos, J.N. 2001. Potential for growth of Listeria monocytogenes on decontaminated beef. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 57-59.

Kain, M.L., Kochevar, S.L., Sofos, J.N., Belk, K.E., Rossiter, C., Reagan, J.O., and Smith, G.C. 2001. Relationship of live animal scores for ambulatory status, body condition, hide cleanliness and fecal matter consistency to microbiological contamination of dairy cow carcasses. Dairy, Food and Environ. Sanit. 21: 990-996.

Kain, M.L., Samelis, J. Sofos, J.N., Belk, K.E. Scanga, J.A., and Smith G.C. 2001. Evaluation of antimicrobials as post-processing solutions against Listeria monocytogenes on sliced pork bologna stored at 4 degrees C in vacuum packages. IFT Annual Meeting, New Orleans, Louisiana, June (Abstract 59E-1).

Kain, M.L., Samelis, J. Sofos, J.N., Scanga, J.A., Belk K.E., and Smith, G.C. 2001. Application of antimicrobials as post-processing solutions to control Listeria monocytogenes on sliced pork bologna stored at 4 degrees C in vacuum packages. Animal Sciences Research Report, CSU, Fort Collins. pp. 59-64.

Kain, M.L., Samelis, J., Sofos, J.N., Belk, K.E., Scanga, J.A., and Smith, G.C. 2001. Treatments to control post-processing contamination by Listeria monocytogenes on sliced pork bologna stored at 4 degrees C in vacuum packages. IAFP Annual Meeting, Minneapolis, Minnesota, August 5-8. (Abstract PO47).

Kiessling, C.R., Cutting, J.C., Loftis, M., Kiessling, W.M. Datta, A., and Sofos, J.N. 2001. Antibiotic resistance of Salmonellae isolated from various food samples. FDA Science Forum, Washington, DC.

Kohls, L.I., Stefanek, J.L., Smith, C.D., Belk, K.E., Scanga, J.A., Sofos, J.N., and Smith, G.C. 2001. A comparison of five different modified atmosphere package methods for retail display-ready ground beef. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 73-76.

O'Rangers, J.J., Clark, S.B., Hurlbut, J.A., Sofos, J.N., Fuerst, B., and Readnour, R.S. 2001. Interlaboratory comparison of methods for the detection of tilmicosin residue in incurred bovine liver. Food and Drug Administration, Laboratory Information Bulletin 4248, 14 pages.

Pedroso, L., Paulo, A., Louca, A., and Sofos, J. 2001. Evaluation of sliced ready to eat hams from Portugal for various types of microbial contamination. Proceedings 47th Int. Congress Meat Science and Technol ., August 26-31, Krakow.Poland. Vol. II, pp. 24-25.

Ransom, J.R., Bacon, R.T., Belk, K.E., Sofos, J.N., Scanga, J.A., and Smith, G.C. 2001. Evaluation of methods for sampling rectal/colonal feces, hides and carcasses to test for presence of Escherichia coli O157:H7 and Salmonella spp. IAFP Annual Meeting, Minneapolis, Minnesota, August 5-8. (Abstract T01).

Ransom, J.R., Bacon, R.T., Belk, K.E., Sofos, J.N., Scanga, J.A., and Smith, G.C. 2001. Evaluation of methods for sampling rectal/colonal feces, hides and carcasses to test for presence of Escherichia coli O157:H7 and Salmonella spp. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 95-98.

Roeber, D.L., Cannell, R.C., Belk, K.E., Sofos, J.N., Scanga, J.A., G .L. Cowman, G.L., and Smith, G.C. 2001. Incidence of injection-site lesions in beef and dairy cow rounds. Journal of Animal Science 79:(Supplement 1) Abstract 264. p. 63.

Roeber, D.L., Cannell, R.C., Belk, K.E., Sofos, J.N., Scanga, J.A., G .L. Cowman, G.L., and Smith, G.C. 2001. Incidence of injection-site lesions in top sirloin butts of fed steers and heifers. Journal of Animal Science 79:(Supplement 1) Abstract 263. p. 63.

Samelis, J., Kain, M.L., Sofos, J.N., Scanga, J.A., Belk, K.E., and Smith, G.C. 2001. Combinations of nisin with organic acids or salts to control post-processing contamination of Listeria monocytogenes on sliced, vacuum packaged pork bologna at 4 degrees C. IAFP Annual Meeting, Minneapolis, Minnesota, August 5-8. (Abstract PO48).

Sloan, E.M., O'Neill, Kaysner, C., DePaola, A., and Sofos, J. 2001. Comparison of two nonradioactive gene probes for the enumeration of Vibrio parahaemolyticus in crabmeat. FDA Science Forum, Washington, DC .

Smith, C.D., Belk, K.E., Sofos, J.N., Scanga, J.A., Kain, M.L., and Smith, G.C. 2001. Effects of activated ozone, on lipid peroxidation, when applied to carcasses and to ground beef during blending. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 91-93.

Smith, C.D., Belk, K.E., Sofos, J.N., Scanga, J.A., Kain, M.L., and Smith, G.C. 2001. Effects of activated ozone, as a decontamination intervention, when applied to hides, carcasses, and to ground beef during blending. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 87-90.

Stefanek, J.L., Kohls, L.I., Smith, C.D., Belk, K.E., Scanga, J.A., Sofos, J.N., and Smith, G.C. 2001. Microbiological quality of ground beef when five case-ready modified atmosphere packing methods are used . Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 111-115.

Stopforth, J.D., Samelis, J., Sofos, J.N., Kendall, P.A., and Smith, G .C. 2001. Biofilm formulation of acid-adapted and nonadapted Listeria monocytogenes in meat decontamination washings. Animal Sciences Research Report, Colorado State University, Fort Collins. pp. 69-72.

Ware, L.M., Kain, M.L., Sofos, J.N., Belk, K.E., Reagan, J.O., and Smith, G.C. 2001. Influence of sampling procedure, handling and storage on the microbiological status of fresh beef. Dairy, Food and Environ. Sanit. 21:14-19.

2002 Bacon, R.T., Sofos, J.N., Belk, K.E., and Smith, G.C. 2002. Commercial application of lacic acid to reduce bacterial populations on chilled beef carcasses, subprimal cuts and table surfaces during fabrication. Dairy, Food and Environ. Sanitation 22:674-682.

Clark, S.B., Nandrea, G.J., Madson, M.R., Sofos, J.N., and Hurlbut, J .A. 2002. Detection of flumixin meglumine and phenylbutazone residues in raw milk by ELISA screening. FDA Science Forum, Washington, DC. February 20-21. (Abstract S7).

Clark, S.B., O'Rangers, J.J., Rowe, W.D., Madson, M.R., Hurlbut, J.A., Sofos, J.N., Fuerst, B., James, G., Griffith, S., and Readnour, R.S. 2002. Interlaboratory comparison of methods for the determination of incurred tilmicosin residues in bovine liver. J. AOAC Int. 85:1260-1267.

Clark, S.B., Turnipseed, S.B., Nandrea, G.J., Madson, M.R., Hurlbut, J .A., and Sofos, J.N. 2002. Confirmation of phenylbutazone residues in bovine kidneys by liquid chromatography/mass spectrometry. J. AOAC Int . 85:1009-1014.

Kain, M.L., Scanga, J.A., Sofos, J.N., Belk, K.E., Reagan, J.O., Buege , D.R., Henning, W.P., Morgan, J.B., Ringkob, T.P., Bellinger, G.R., and Smith, G.C. 2002. Consumer behavior regarding time lapse between store-purchase and subsequent home storage of fresh beef retail cuts. Dairy, Food and Environm. Sanitation 22:740-744.

Pedroso, L., Louca, A., and Sofos, J. 2002. Investigation for potential sites of microbial contamination on sliced ready-to-eat meat products. IAFP Annual Meeting. San Diego, CA, June 30-July 3 (Abstract P170).

Ransom, J.R., Belk, K.E., Bacon, R.T., Sofos, J.N., Scanga, J.A., and Smith, G.C. 2002. Comparison of sampling methods for microbiological testing of beef animal rectal/colonal feces, hides and carcasses. J. Food Prot. 65:621-626.

Ransom, J.R., Belk, K.E., Sofos, J.N., Scanga, J.A. and Smith, G.C. 2002. Comparison of intervention technologies for reducing Escherichia coli O157:H7 on beef cuts and trimmings. IAFP Annual Meeting. San Diego, CA, June 30-July 3 (Abstract T61).

Roeber, D.L., Belk, K.E., LaValley, S.B., Scanga, J.A., Sofos, J.N., and Smith, G.C. 2002. Producing consumer products from sheep: the sheep safety and quality assurance program. Proc. Western Section, American Society of Animal Science, Vol. 53:1-4.

Roeber, D.L., Cannell, R.C., Wailes, W.R., Belk, K.E., Scanga, J.A., Sofos, J.N., Cowman, G.L., and Smith, G.C. 2002. Frequencies of injection-site lesions in muscles from rounds of dairy and beef cow carcasses. J. Dairy Sci. 85:532-536.

Roeber, D.L., Cannell, R.C., Wailes, W.R., Belk, K.E., Scanga, J.A., Sofos, J.N., and Smith, G.C. 2002. Frequencies of injection-site lesions in muscles from rounds of dairy and beef cow carcasses. Department of Animal Sciences, Colorado State University. Animal Science Research Report. pp. 73-76.

Samelis, J. and Sofos., J.N. 2002. The role of glucose in enhancing the temperature-dependent growth inhibition of Escherichia coli O157:H7 by Pseudomonas. Appl. Environ. Microbiol. 68:2600-2604.

Samelis, J., Sofos, J.N., Kain, M.L., Scanga, J.A., Belk, K.E., and Smith, G.C. 2002. Control of Listeria monocytogenes with combined antimicrobials following post-process contamination and extended storage of frankfurters at 4 degrees C in vacuum packages. J. Food Prot. 65:299-307.

Shaw, C.I., Sofos, J.N., and Burns, C.L. 2002. Excel spreadsheet for pH analysis. Food and Drug Administration, Laboratory Information Bulletin 4279, 5 pages.

Shaw, C.I., Sofos, J.N., and Burns, C.L. 2002. Linear regression spreadsheet for water activity analysis. Food and Drug Administration, Laboratory Information Bulletin 4288, 10 pages.

Smith, G.C., Belk, K.E., Scanga, J.A., and Sofos, J.N. 2002. Current Issues In The Beef Industry And Their Impact On The Cow/Calf Sector. pp. 1-29. Presented at the Judith Basin Cattlemen's Association Field Day, (Stanford, MT), at the Georgia Cattlemen's Association Annual Convention (Perry, GA) and at the Mississippi Cattlemen's Association Annual Convention (Jackson, MS).

Smith, G.C., Belk, K.E., Scanga, J.A., and Sofos, J.N. 2002. Current Issues In The Beef Industry And Their Impact On The Cow/Calf Sector. pp. 1-28. Presented to the Texas Beef Council. (Austin, TX).

Smith, G.C., Belk, K.E., Scanga, J.A., and Sofos, J.N. 2002. Current Issues In The Beef Industry And Their Impact On The Cow-Calf Sector. pp. 1-27. Presented at the national meeting of the Cattleman Corporation of Costa Rica. (San Jose, Costa Rica).

Smith, G.C., Belk, K.E., Scanga, J.A., Sofos, J.N., and Tatum, J.D. 2002. Traceback, Traceability And Source Verification In The U.S. Beef Industry. Proceedings of the IX Simposio Centroamericano y del Caribe Sobre Procesamiento de Carnes (Cartago, Costa Rica). pp. 21-32.

Smith, G.C., Sofos, J.N., Belk, K.E., and Scanga, J.A. 2002. Just The Facts, Mom!! Food Safety Risks From Foodborne Pathogens, Chemical Residues, Genetically Modified Organisms, Foreign Animal Diseases, And Food Bioterrorism. pp. 1-14. Presented to the Southern Colorado Dietetics Association. (Colorado Springs, CO).

Smith, G.C., Sofos, J.N., Belk, K.E., Scanga, J.A. 2002. The Blame Game: Foodborne Illness, Hormones, Antibiotics, B.S.E. And Food Bioterrorism. pp. 1-4. Presented to the Wisconsin Dietetics Association. (Oshkosh, WI).

Sofos, J. N. 2002. Decontamination methods at slaughter. Presented at Pathogen Reduction: A Scientific Dialogue.A Scientific Symposium sponsored by the Food Safety and Inspection Service of the United States Department of Agriculture. Washington, DC, May 6-7.

Sofos, J.N. 2002. Additives and interventions in processed meats. IAFP Annual Meeting. San Diego, CA, June 30-July 3.

Sofos, J.N. 2002. Biofilm formation by Listeria monocytogenes in fresh beef decontamination washings. 48th Int. Congress of Meat Science and Technology. Rome, Italy, August 25-30.

Sofos, J.N. 2002. Foodborne diseases - Emerging pathogens. Food Protection 2002 - International Conference. Monte de Caparita, Lisbon. Portugal, February 22-23.

Sofos, J.N. 2002. Foodborne pathogenic microorganisms. GSD Seminar. Colorado State University, Fort Collins, Colorado, March 18.

Sofos, J.N. 2002. Foodborne safety objectives. Food Protection 2002 - International Conference. Monte de Caparita, Lisbon. Portugal, February 22-23.

Sofos, J.N. 2002. Listeriosis - Recent outbreaks in the USA associated with processed meats; Industry strategies for control. Food Protection 2002 - International Conference. Monte de Caparita, Lisbon. Portugal, February 22-23.

Sofos, J.N. 2002. Microbial foodborne illness update. SX Seminar. Colorado State University, Fort Collins, Colorado, December 13.

Sofos, J.N. 2002. Microbiological criteria and testing. Food Protection 2002 - International Conference. Monte de Caparita, Lisbon. Portugal, February 22-23.

Sofos, J.N. 2002. Microbiological hazards on meat and meat products; National programs to reduce contamination. Invited keynote speech at the II Seminario Internacional Fundisa, October 2-3, Madrid, Spain.

Sofos, J.N. 2002. Microtesting: the good and the bad. Food Safety Symposium. Food Safety Net Services. San Antonio, Texas. April 29-30.

Sofos, J.N. 2002. Pathogen control with chemical additives in muscle foods. IFT Annual Meeting, Anaheim, CA, June 15-19.

Sofos, J.N., Belk, K.E., Rossiter, C., Reagan, J.O., and Smith, G.C. 2002, Live dairy cull cow characteristics and associated microbial contamination, In: Frans J.M. Smulders. John D. Collins (Eds.) Food Safety Assurance and Veterinary Public Health; Volume 1 Food Safety Assurance in the Pre-Harvest Phase, Publ. Wageningen Academic Publishers, Wageningen, The Netherlands. ISBN 9076998051, pp. 330-332.

Stefanek, J.L., Belk, K.E., Scanga, J.A., Sofos, J.N., and Smith, G.C. 2002. Review Of Intervention Technologies Available For Decontamination Of Carcasses. Submitted to Purac America, Inc. Center for Red Meat Safety, Department of Animal Sciences, Colorado State University, Fort Collins, CO. pp. 1-36.

Stefanek, J.L., Ransom, J.R., Sofos, J.N., Scanga, J.A., Belk, K.A. and Smith, G.C. 2002. The Potential Of Using Ozone As A Decontaminant In Beef Slaughtering/ Dressing And/Or Fabrication. Final Report to PRAXAIR, Inc. Center for Red Meat Safety, Department of Animal Sciences, Colorado State University, Fort Collins, CO. Pp. 1-50.

Lactate and Humans

Biological Work

- **Muscle Contraction** *
- Digestion & Absorption
- Gland Function
- Establishment of Gradients
- Synthesis of New Compounds

Energy

- First Law of Thermodynamics
  - Conservation of Energy – Energy can not be “Created” or “Destroyed”
  - Our body simply transforms energy

Adenosine Tri Phosphate

"Fuel" for all processes in body

- Food energy → Rebuild more ATP
- ATP – Chemical, Potential Energy
- Phosphate bonds: "High Energy"

Phosphorylation

- ATP $\longleftrightarrow$ ADP + P + **ENERGY**
- CP $\longleftrightarrow$ C + P + **ENERGY**

ATP Re-synthesis

Aerobic vs. Anaerobic Energy

- Aerobic: O_2 requiring energy production
- Anaerobic: No O_2 required for energy

Anaerobic Energy

- ATP stores
- Creatine Phosphate
- Anaerobic glycolysis

ATP – CP Energy System

- Small amount of ATP stored
  - 85 g in whole body
  - Must be re-synthesized
  - CP: quick energy for ATP rebound
    - CP stored in larger quantities
- All out Exercise – 5 to 8 seconds

ATP – CP Energy System

- Increasing [ATP – CP]
  - Exhaust ATP – CP stores → Adaptation
  - Creatine Monohydrate supplementation

Creatine Monohydrate

- What it does
  - Increases intracellular stores creatine phosphate.
  - Increases **anaerobic** capacity
  - Decreases accumulation of lactic acid*
  - Delays onset of muscular fatigue
  - Increase water retention in muscle*

Creatine Monohydrate

- What it does **NOT** do:
  - Make you stronger / faster
  - Increase muscle mass
  - Decrease body fat %
  - Increase aerobic capacity

Creatine Monohydrate

- Side Effects?
  - Muscle cramps, pulls, strains, etc.
  - Dehydration
  - Liver / Kidney stress
  - Atrophy of bank account

Anaerobic Glycolysis

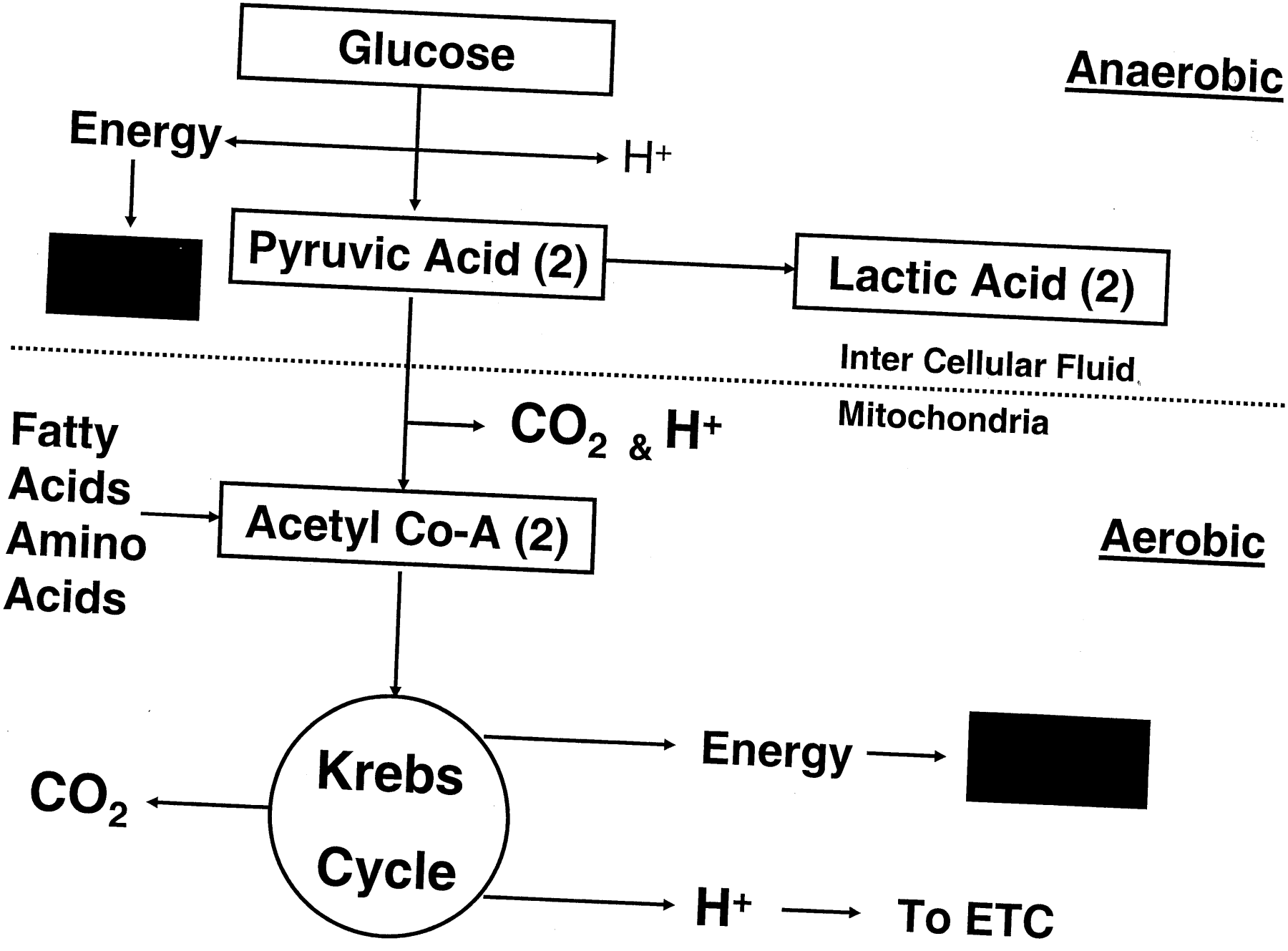
- 6-Carbon Glucose → two 3-carbon pyruvic acid
- Occurs in “watery medium”
- 5% of total ATP from glucose

Anaerobic Glycolysis

1.) Chemical bonds broken

2.) H^+ atoms are striped

3.) Two ATP formed

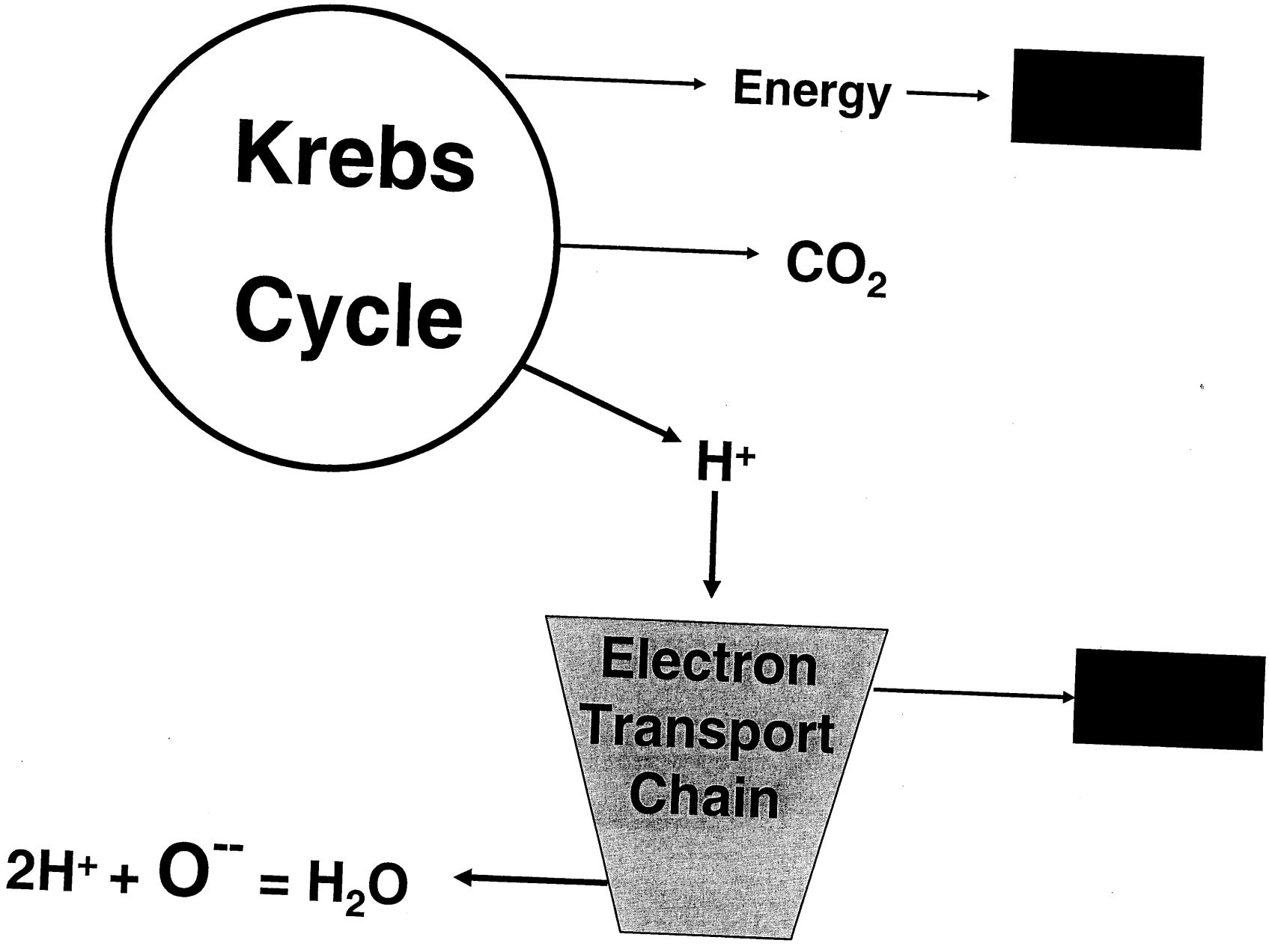

Glucose
Anaerobic
Energy
H+
Pyruvic Acid (2)
Lactic Acid (2)
Inter Cellular Fluid
Mitochondria
CO2 & H+
Fatty Acids
Amino Acids
Acetyl Co-A (2)
Aerobic
Krebs Cycle
CO2
Energy
H+
To ETC

Aerobic Glycolysis

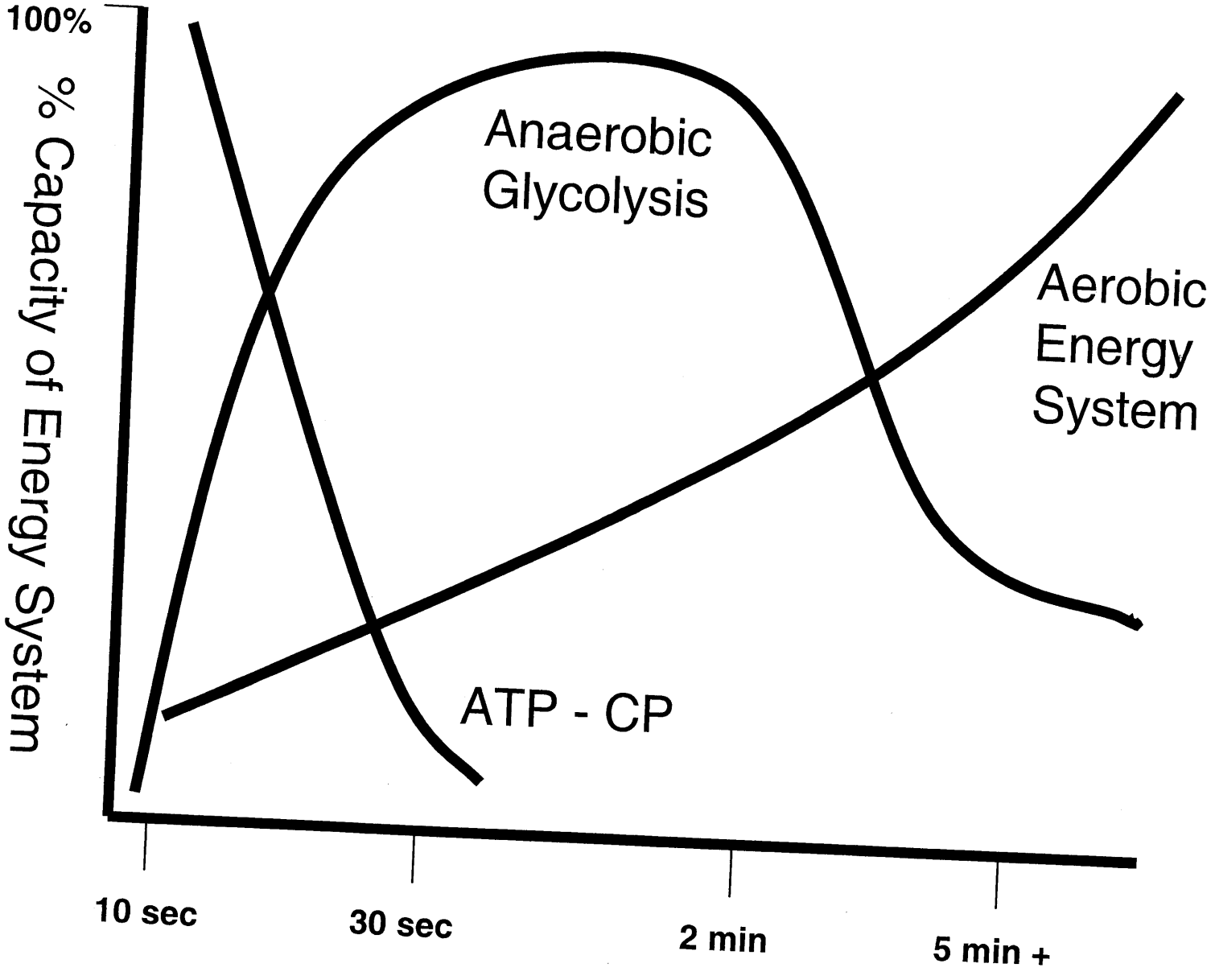
- Pyruvic Acid $\rightarrow$ Acetyl CoA
- Acetyl CoA $\rightarrow$ Mitochondria
- Krebs Cycle
  - Chemical breakdown of Acetyl CoA & fragments of proteins & Lipids
  - Frees H^+ & Produces CO_2
  - Generates small Amount of ATP

Aerobic Glycolysis

- Krebs Cycle
  - $H^+ \rightarrow$ Electron Transport Chain
- ETC
  - H^+ + Oxygen $\rightarrow H_20$ + Energy


Krebs Cycle
Energy
CO_2
H^+
Electron Transport Chain
$2H^+ + O^{--} = H_2O$

Energy Transfer Systems and Exercise



Aerobic Capacity

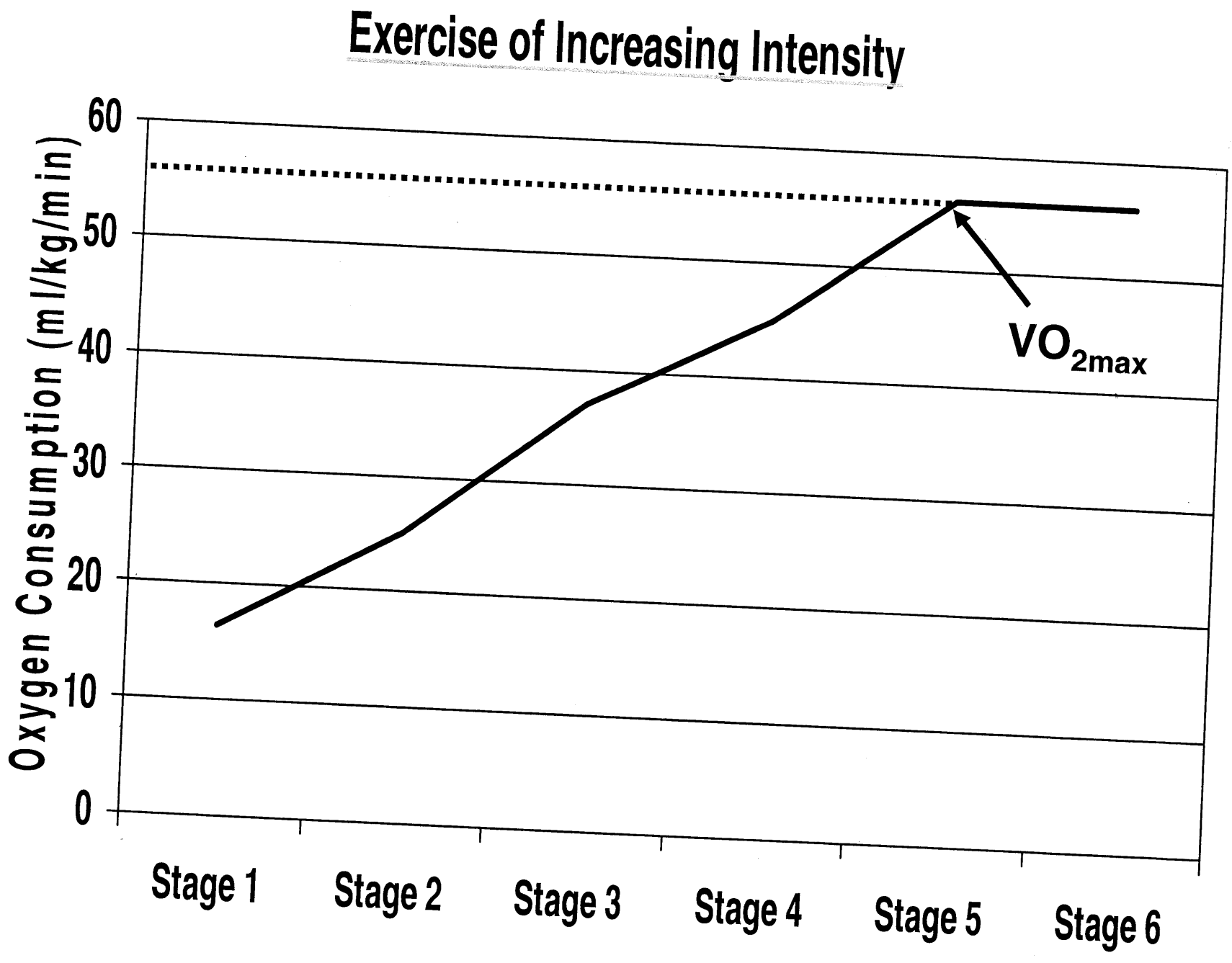
Capacity for aerobic resynthesis of ATP

O_2 Uptake During Exercise

- Oxygen Uptake: Use of oxygen by the cells for aerobic metabolism.
  - VO_2 – ml O_2/Kg/min.
  - $VO_{2\,max}$ = Max O_2 uptake possible by individual
  - Quantification of Aerobic Capacity

VO_{2max}

- VO_{2max} : Max Oxygen Uptake
  - Further increases in exercise intensity (further energy requirement), results in **NO** increase in VO_2.
  - **Additional energy is produced via anaerobic glycolysis**


Exercise of Increasing Intensity
Oxygen Consumption (ml/kg/min)
60
50
40
30
20
10
0
VO2max
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6

What Effects Energy Capacity ?

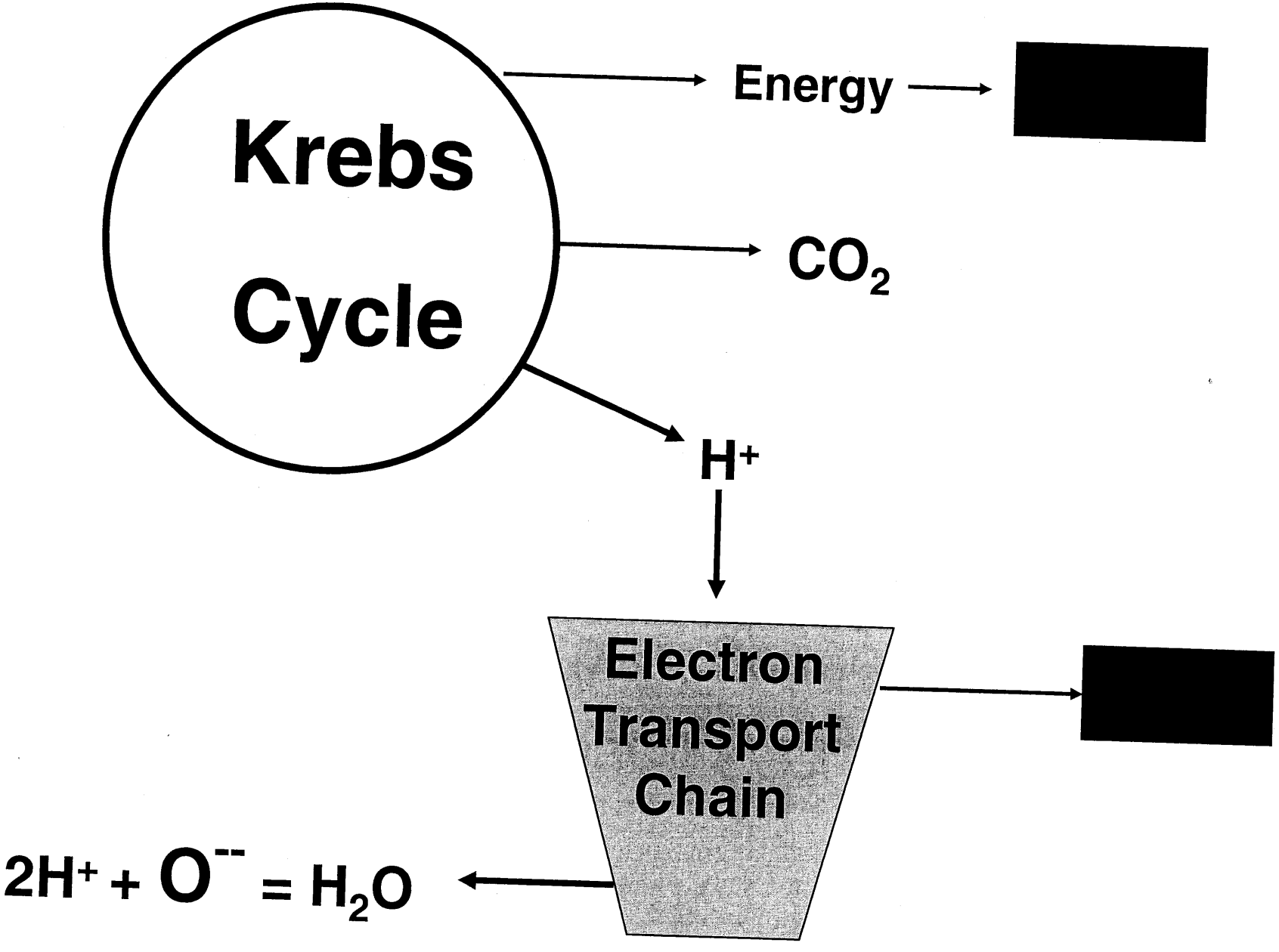
- Diet (Glycogen stores, Metabolic State)
- Training
  - Type of training, Altitude
- Gender
- Supplements / Drugs
- GENETICS

Energy Systems and Exercise

- Anaerobic / Aerobic Energy is always being produced
  - Exercise intensity / duration determines the ratio
- Can be estimated with RER

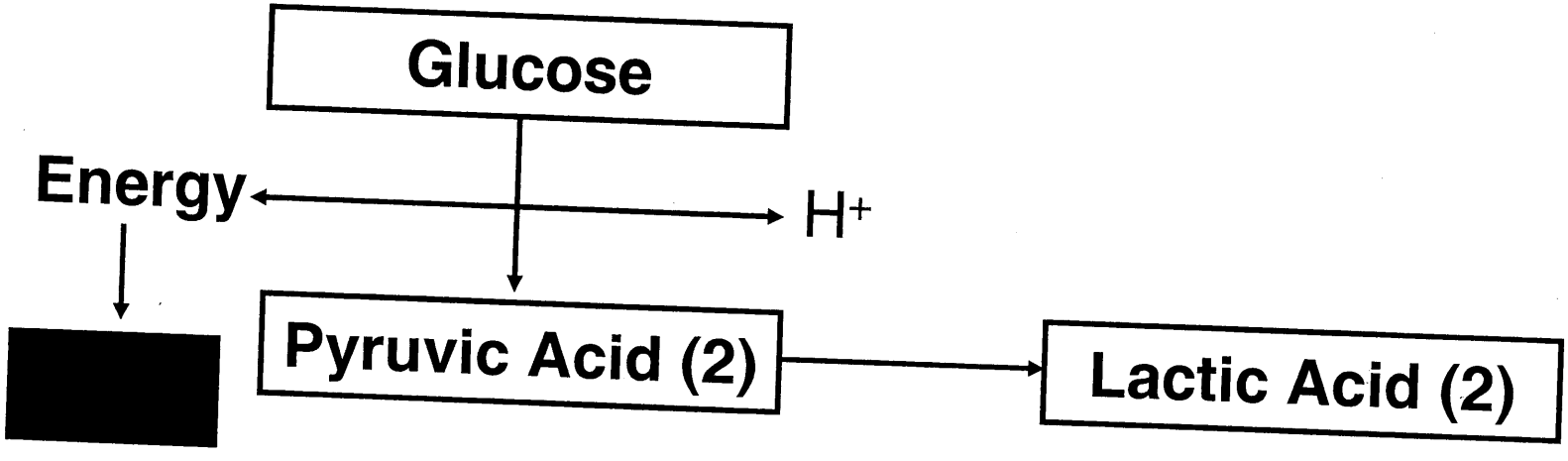
RER aka RQ

- RER = CO_2 produced / O_2 consumed
- Carbohydrate: Hydrogen to Oxygen (2:1) $\rightarrow$ RER = 1.00
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
- Lipid: Hydrogen > Oxygen (2:1) $\rightarrow$ RER = 0.7


Krebs Cycle
Energy
CO_2
H^+
Electron Transport Chain
$2H^+ + O^{--} = H_2O$

Lactic Acid

- Byproduct of Anaerobic Metabolism.



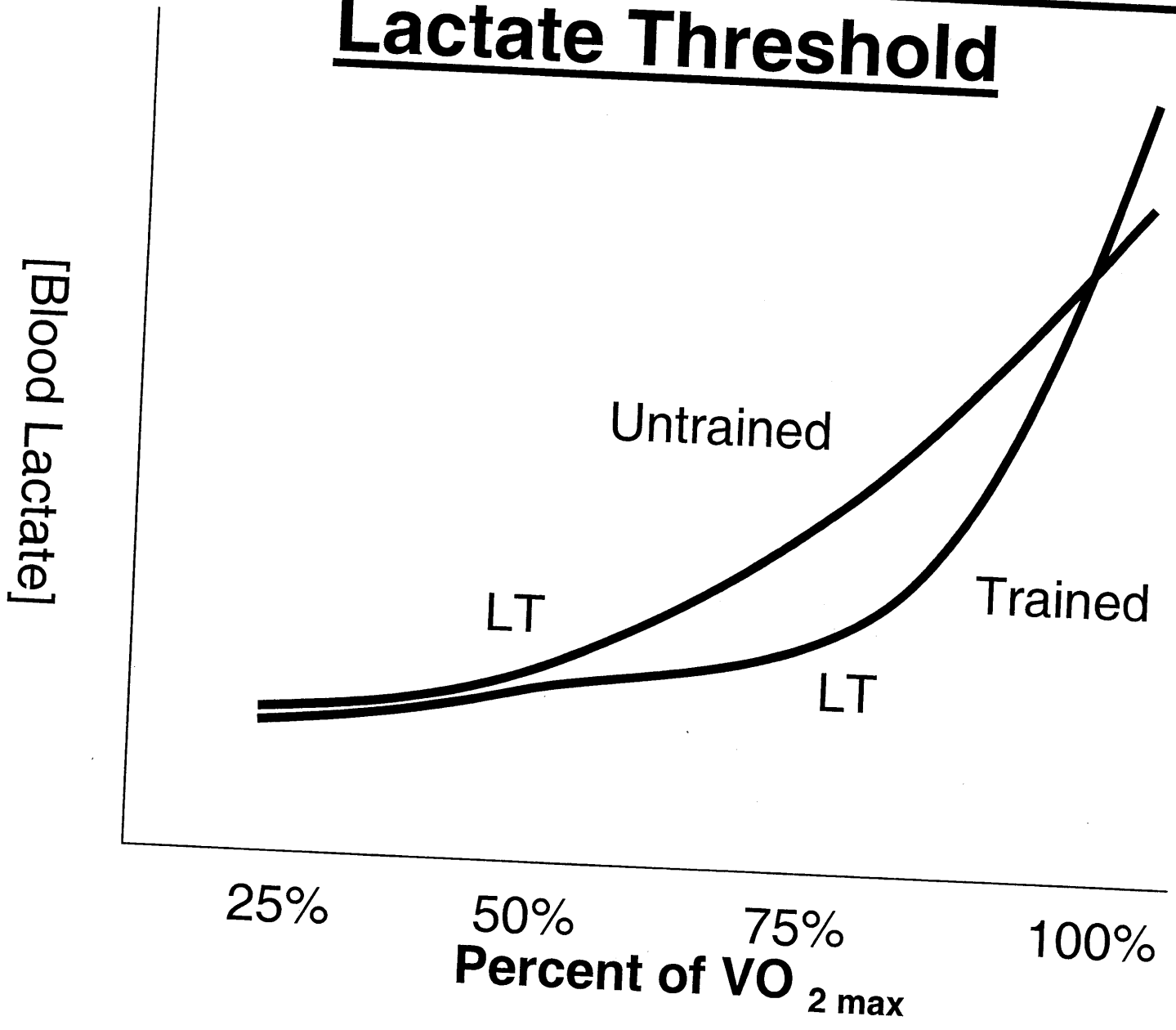
Lactic Acid

- Causes Fatigue
  - Irritation of local muscle
  - Decreased pH of cellular environment & bloodstream
- Training increases lactate tolerance and decreases lactate formation at any given workload (by 20-30%)

Blood Lactate Threshold

- Point at which lactate begins to dramatically increase in the blood stream. (55% VO_{2max})
  - Fatigue increases exponentially
  - Caused by increase in anaerobic metabolism → Lactate production

Effect of Training on Blood Lactate / Lactate Threshold



What Effects Lactic Threshold ?

- GENETICS
  - Aerobic Capacity
  - Fiber Type
- Training
  - (adaptations..next slide)

Physiological ☺'s with Training (↓ Lactic Acid Build Up)

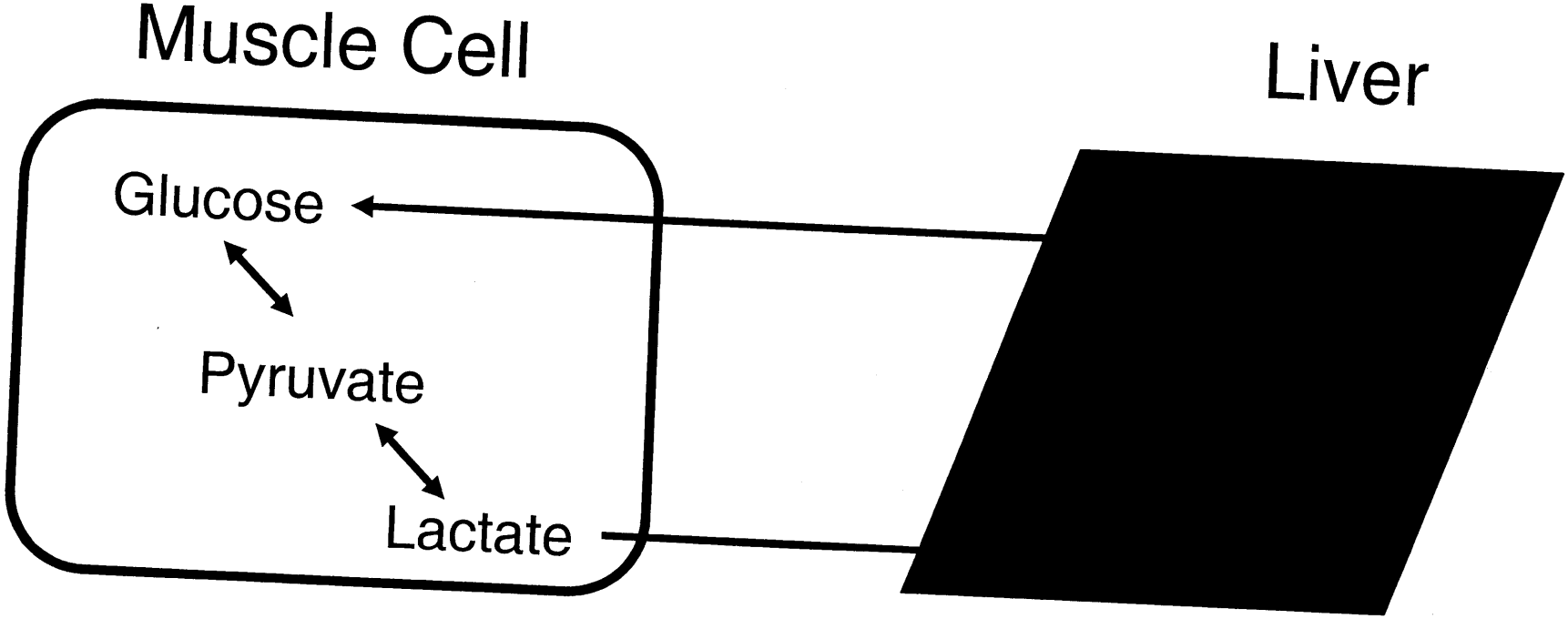
- ↑ in capillaries (↑ Density)
- ↑ aerobic enzymes
- ↑ mitochondria (# and size)
- ↑ Pain tolerance to Lactic Acid

Blood Lactate Threshold

- Lactate appearance in the bloodstream
  - POWERFUL predictor of aerobic exercise performance!
  - Higher LT = Better performance; less LA buildup, less fatigue

Lactate Processing

Cori Cycle



Recovery

- Recovery Oxygen Uptake
  - VO2 stays ↑ after exercise
    - Replenish ATP – CP
    - Reload hemoglobin
    - Supply elevated energy needs to cardiovascular system
    - Increased O_2 need 2° heat

Recovery (cont.)

- Lactic Acid Removal (Heavy Exercise)
  - Cori cycle
  - Reconversion in muscle cell
    - Lactate $\rightarrow$ Pyruvate $\rightarrow$ Glucose
  - Few seconds – few hours

Recovery (cont.)

- Light activity accelerates recovery
  - Increased blood flow to muscle, liver, and heart
    - All can oxidize lactate for energy

Miscellaneous Information

PURASAL® at a glance

PURAC

Benefits of using PURASAL in Meat & Poultry products

PURASAL, sodium and potassium lactate, is a natural ingredient used in processed meat and poultry products. It extends the shelf life and increases the safety of meat & poultry products.

Natural

- Sodium and potassium lactate are the salts of L(+)-lactic acid.
- Lactic acid is naturally present in both the animal and human body.
- Lactic acid is a natural product, produced by fermentation from corn or beet sugar.

PURASAL *increases food safety*

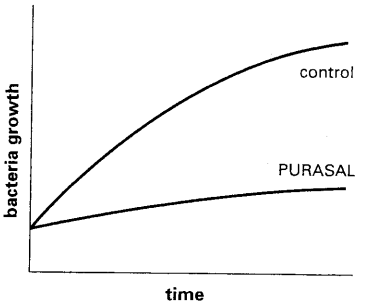
- PURASAL controls pathogens such as *Listeria monocytogenes*, Salmonella and *Clostridium botulinum.*
- Increases the intrinsic safety.
- Offers additional protection against cross contamination and abuse.

PURASAL *extends shelf life*

- PURASAL gives the opportunity of longer production runs.
- Offers longer shelf life at the retailer.
- Retailers will have less returns of spoiled meat & poultry products.
- It offers extra protection in case of temperature abuse.

PURASAL *enables product innovation*

- For sliced, diced or shaved products
- For low salt products
- For low fat or fat-free products
- Convenience packaging



PURASAL *increases efficiency*

- Longer production runs (longer production hours, fewer changes during production runs).
- Increases cooking yield.
- Increases the slicing yield of meat & poultry products.

Other PURASAL product properties

- **For fresh meat products:**
  - Increased tenderness
  - Less purge/drip formation
  - Helps to preserve the color
- **For cooked products:**
  - Improved cake distribution
  - Less purge during cooking
  - Increased cooking yield

Why buy PURASAL from PURAC?

- **Global leader of the lactic acid and lactates market**
  - 4 plants and a worldwide network of sales offices and warehouses
- **Highest quality product**
  - GMP
  - Product Quality is guaranteed by Certificate of Analysis
- **Innovator**
  - Innovator of new solutions for the meat and poultry industry
  - New ingredient applications for meat and poultry products
- **Technical support**
  - Application research for customers is possible
  - Experienced staff (food technologists & meat industry professionals)
  - Global know-how of the meat & poultry industry

For more information, please contact your local PURAC office or visit:
www.purac.com/meatandpoultry

PURAC

PURAC biochem, The Netherlands
Phone +31 183 695 695
E-mail pnl@purac.com

PURAC UK, United Kingdom
Phone +44 121 236 1828
E-mail puk@purac.com

PURAC Poland, Poland
Phone +48 22 616 1852
E-mail ppl@purac.com

PURAC Germany, Germany
Phone +49 6721 181740
E-mail pge@purac.com

PURAC Russia, Russia
Phone +7 095 974 1521
E-mail pru@purac.com

PURAC bioquímica, Spain
Phone +34 93 568 6300
E-mail psp@purac.com

PURAC Hungary, Hungary
Phone +36 30 231 8808
E-mail phu@purac.com

PURAC France, France
Phone +33 47 211 4667
E-mail pfr@purac.com

PURAC America, U.S.A.
Phone +1 847 634 6330
E-mail pam@purac.com

PURAC sínteses, Brasil
Phone +55 11 3062 1535
E-mail pbr@purac.com

PURAC Asia Pacific, Singapore
Phone +65 6349 1350
E-mail pap@purac.com

PURAC China, China
Phone +86 21 6875 4755
E-mail pcn@purac.com

PURAC Japan, Japan
Phone +81 3 5728 6700
E-mail pjk@purac.com

www.purac.com

Copyright © 2003 PURAC. All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein. In addition, nothing contained herein shall be construed as a recommendation to use any products in conflict with existing patents covering any material or its use.

03/03

FOCUS

PURAC

Challenges in uncured meat

Uncured meat special

Uncured meat markets for wholesome meat products with added value are continuously increasing. Uncured meat products are becoming more popular because of their healthy image. But the safety shelf-life of these products is vital to their commercial success. This issue of FOCUS describes the advantages of PURASAL® in a variety of uncured meat applications.

The demand for meat products is changing as quality and safety become more important.

General trends

The consumption of traditional fresh meat at home has been largely replaced by the consumption of further processed meat products - chilled and added value products in particular.
In the next few years, elderly people are more likely to begin demanding premium foods. A significant need for inexpensive food, or for more moderate and standard quality, will continue. However, we will also witness a growing number of consumers who will be increasingly ready to pay a premium for genuine quality improvement. Meat companies must decide on positioning themselves to meet the phenomenon or market polarization.

Health trend

Consumers are willing to reduce their fat intake, but only if the taste matches the quality of the products' regular full-fat version. And fresh is best.
Western consumers are concerned about fat intake, nutrient content and safety. Yet ranked in order of importance, a product should be tasty, priced right, convenient, fat free and consist of natural ingredients. This health trend leads to an increased consumption of poultry meat and products with a low sodium content. PURASAL, natural L+-sodium and potassium lactates, offers processors an additional tool for manufacturing safe and healthy products. The effectiveness of all PURASAL products is the same.

Industry trend

Food safety is of paramount importance in the food industry. Recalls due to the reduced safety of a food product are the nightmare of every manufacturer.
They are very costly and result in loss of market share and a damaged product image. Retailers are more and more demanding that producers take responsibility for the quality of the end product and ensure food safety standards. Concepts such as HACCP and GMP are applied in the food industry to assure safety.

PURASAL S	Sodium lactate
PURASAL Lite	Sodium/Potassium lactate
PURASAL P	Potassium lactate

Markets for value-added uncured meat products are increasing, but the safety and shelf life of such products determine its commercial success. PURASAL can greatly expand the market for these products.

Shelf life

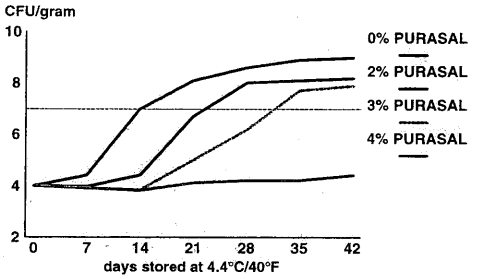
PURASAL is widely used in the processed meat industry as a natural antimicrobial agent to extend shelf life. In cooked uncured meat products shelf life can be extended from 50% to 100%.

Pathogen control

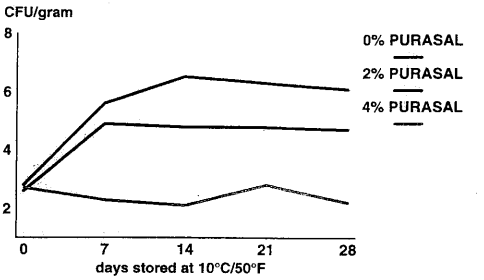
In uncured products the only hurdles against pathogenic bacteria are storage temperature and control of water activity. Cooked turkey breast is low in fat, low in salt, mostly vacuum packed, and has at least a 90-day refrigerated shelf life. The non-proteolytic psychrotrofic spores of *Clostridium botulinum* can be a crucial risk for these kinds of products. Studies of the antimicrobial activities of sodium lactate have demonstrated its inhibitory effects on spoilage bacteria and pathogens. In addition, delayed toxin production by proteolytic types A & B of *C. botulinum* was reported in turkey products. (Maas 1989)
The toxin production by the non-proteolytic strains type B & E is delayed by increasing the concentration of lactate in vacuum packed cooked turkey meat. (Meng 1993)

PURASAL at 3 and 4% also controls the proliferation of *Salmonella typhimurium, Listeria monocytogenes* and *E. coli 0157:H7*, in comparison with control products (without lactate) under refrigerated storage conditions.

Shelf life of a vacuum packed uncured chicken roll



PURASAL controls *E.coli 0157:H7*
(inoculated roast beef)

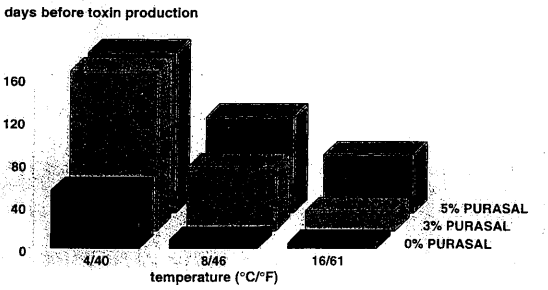


Sous vide

Sous vide products are minimally processed pasteurized food products which possess extended durability under refrigeration.

The food products are placed in high-barrier plastic pouches, which are vacuum sealed and thermally processed. A good cold chain is of paramount importance for these products, which have received only a mild heat treatment. Weak points in the cool chain are the refrigerating retail cabinet and the household refrigerator. The big advantage of sous vide processing is the maintenance of flavor and nutrients. Specific intrinsic barriers are necessary to control the outgrowth of pathogens in sous vide products. *Clostridium botulinum* forms spores that are very resistant to high temperatures. Meat and fish products may contain spores of the toxic *Clostridium botulinum* type E. The addition of PURASAL to these products inhibits the formation of toxins. In an experiment with inoculated products, beef and salmon became toxic within eight days in the absence of PURASAL. At 8°C/46°F storage temperature and an addition-level of 3% PURASAL no toxin was formed within 90 days.

Clostridium Botulinum toxigenisis
(inoculated in turkey breast)



Turkey and chicken breast

In cooked uncured meat products the shelf life is limited by the formation of off-odors and by safety aspects.

PURASAL added to a vacuum packaged chicken-roll can increase shelf life from 14 to 30 days. Raw poultry products have a short shelf life based on microbial counts because they may have a high initial count and because pathogens are quite often present in poultry.

Poultry products are often used as healthy meat items, and for the same reason the salt level is on the low side. For low-sodium products, PURAC developed PURASAL LITE, a formulation based on sodium and potassium lactates or PURASAL P, pure potassium lactate. Both products can be applied in the same way as sodium lactate.

The safety of a good part of our meat supply depends on nitrite, which is a widely used meat preservative. Nevertheless, a disadvantage is that residual nitrite may react with amines and amino acids in meat, leading to the production of N-nitrosamines, which are suspected to be carcinogenic. Therefore nitrite-free meat products are being sought for health reasons.

Nitrite is an antimicrobial agent that retards the germination of spores and the formation of the deadly neurotoxin of *Clostridium botulinum*. Next to its antimicrobial properties, nitrite stabilizes the red color of cooked meat products. PURASAL is a proven antimicrobial agent, effective in inhibiting a wide range of spoilage bacteria and also very effective in the inhibition of *Clostridium botulinum* spore germination and toxigenesis.

Undesirable pink coloration

The occurrence of undesirable pink coloration in uncured cooked meats is a long-standing problem in the meat and poultry industry. Complaints concerning this problem essentially involve the development or persistence of pink coloration in products normally expected to be gray/brown in color.
Pink coloration is often taken as an indication of undercooking. The problem is of special concern with cooked poultry, uncured sliced cooked meats such as roast pork and bratwurst.

There are several factors besides undercooking that can cause the red or pink color in cooked meats:

- Nitrite-induced pinking caused by cross contamination from cured meat operations.
- Nitrite-induced pinking stemming from reduction of nitrate that is widely found as a contaminant in potable water and food ingredients.
- Exposure of meat to combustion gases containing carbon monoxide or nitric oxide, resulting in surface pink color development.
- High pH, which stabilizes myoglobin to heat, leading to red color after cooking.

concentrations as low as 1 ppm can lead to sufficient nitric oxide to cause pink coloration in meat that is subsequently cooked.

Nitrate from water or other sources can be reduced by several bacteria found in meat products are quite potent nitrate reducers. The nitrite so formed can generate nitric oxide by the normal curing mechanism.
PURASAL will inhibit the growth of these nitrate-reducing bacteria and in doing so will prevent the formation of nitrite and pink discoloration.

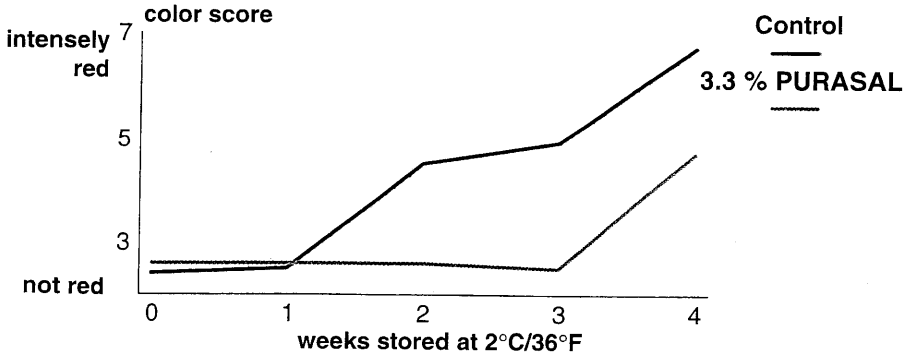
Bratwurst

Bratwurst, a cooked sausage, is an uncured product with the gray color typical of cooked meats. However, a red surface can develop during refrigerated storage, and consumers may assume that such products are undercooked.

The pigment metmyoglobin causes the gray color. Metmyoglobin can be reduced to myoglobin, and myoglobin can be oxidized to oxy-myoglobin, which produces a red color. The reduction of met-myoglobin to myoglobin by reductive by-products of anaerobic microbial growth is the probable cause of red discoloration in vacuum packaged bratwurst. Antimicrobial agents can reduce color problems and extend shelf life.

The addition of PURASAL proved to work well in stabilizing color. In tests red discoloration first occurred in samples without lactate. This was related to a higher mean of aerobic and anaerobic plate count. An addition of 3.3% delayed the formation of red discoloration by two weeks.

Bratwurst, color development



Legislation in the USA

Lactic acid and lactates are naturally present in meat products and are considered safe by the joint FAO/WHO Expert Committee on food additives. Since the meat industry and its products are very well regulated, the use of sodium and potassium lactates needs to be approved in most countries.

In all products covered by Regulation 9 CFR 319.180 lactates (sodium lactate, potassium lactate) are permitted in a quantity not exceeding 2% of the total formulation, meaning that 3.3% PURASAL may be used in all meat products where flavors are allowed. In all products that are cooked thermically sealed and not covered by this regulation, lactates up to 4.8% of the formulation (total) are permitted. The use of 1.7% to 2% lactates to delay the growth of *Clostridium botulinum* in poultry and fish products that are uncured, cooked and packaged in a plastic barrier package is part of a patented technology. The method is described in US patents no. 4,728,529, 4,888,191 and 5,017,891. PURACO America Inc. is the exclusive licensee for the above US patents and will, on request, sub-license any processor of poultry and fish to employ the patented invention for a reasonable royalty, using lactates from any source whatsoever.

PURASAL has been shown to enhance the cooked beefy/brothy flavor and to limit this flavor's subsequent decline during refrigerated storage in cooked beef roasts.

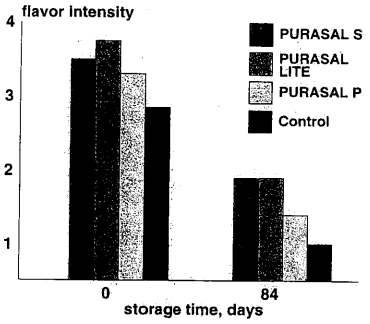
When PURASAL was added, the cooked beef/brothy flavor was enhanced at zero days of storage. During storage this flavor declined, but the products containing PURASAL LITE or PURASAL S tended to maintain higher levels of cooked beefy/brothy aromatics compared with control roasts. In addition, lactate tends to limit the development of aromatics associated with Warmed Over Flavor (WOF).

PURASAL LITE is excellent in low-salt products because it offers the opportunity to reduce sodium content in the meat product while maintaining optimal flavor.

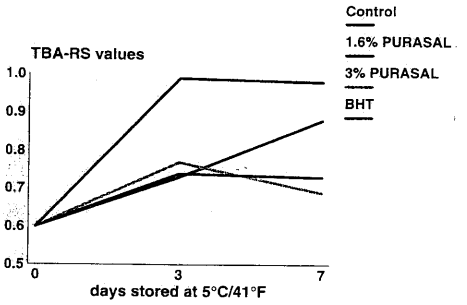
PURASAL as antioxidant

PURASAL possesses antioxidant activity of an unknown mechanism. Based on TBA-RS values (a scale for measuring fat oxidation), sodium lactate suppresses oxidation in pork for up to seven days of storage if kept below 5°C/41°F. Under these conditions the antioxidant activity is similar to the antioxidant activity of BHT. (Nnanna 1994)

Effect of PURASAL on the beefy/brothy flavor of cooked beef

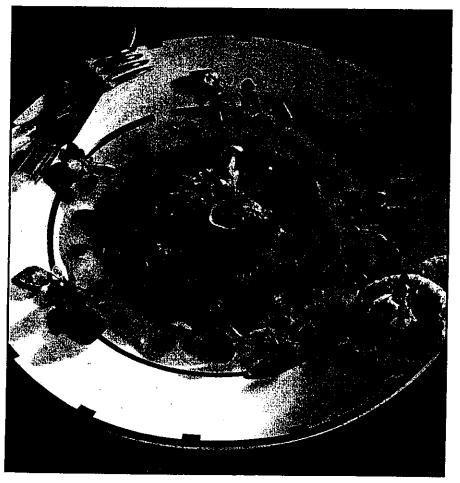


PURASAL inhibits fat oxidation



Roast beef

Changing lifestyles have led to an increased demand for convenient, ready to eat products.



Through their buying habits, time-conscious consumers have shown that value-added cooked beef products have an important market share in the food industry. However, the absence of nitrite in roast beef makes this product sensitive to the spread of pathogenic bacteria. Both shelf life and safety are very important to the commercial success of these products.

Various research data have proven that lactate is a very effective bacteriostatic agent. Extensive research at a.o. Texas A&M university proved that a spoilage level of one million bacteria per gram, the usage level of 3% PURASAL, extended the shelf life of roast beef from 20 to more than 40 days. The use of 3% to 4% PURASAL in inoculated roast beef fully suppressed the growth of pathogens such as *S. typhimurium, L. monocytogenes* and *E.coli O157:H7.*

In addition to shelf-life extension and product safety, the use of lactate in roast beef results in a higher cooking yield and in a darker, redder color with less gray surface area. Trained panel evaluations revealed positive flavor notes. Consumer panelists described treated roasts as flavorful with stronger beefy, meaty flavor than control samples.
3% PURASAL is the optimum level for its use as a bacteriostatic agent and as a flavor enhancer in cooked uncured beef.

PURAC

PURAC biochem, The Netherlands
Phone +31 183 695 695
Fax +31 183 695 600
E-mail: pnl@purac.com

PURAC UK, United Kingdom
Phone +44 121 236 1828
Fax +44 121 236 1401
E-mail: puk@purac.com

PURAC Germany, Germany
Phone +49 6721 181740
Fax +49 6721 181750
E-mail: pge@purac.com

PURAC Poland, Poland
Phone +48 22 616 1852
Fax +48 22 617 8567
E-mail: ppl@purac.com

PURAC bioquimica, Spain
Phone +34 93 568 6300
Fax +34 93 568 3955
E-mail: psp@purac.com

PURAC America, U.S.A.
Phone 847 634 6330
Fax 847 634 1992
E-mail: pam@purac.com

PURAC China, China
Phone +86 21 6875 6974
Fax +86 21 6875 6974
E-mail: pcn@purac.com

PURAC Far East, Singapore
Phone +65 220 6022
Fax +65 222 1707
E-mail: pfe@purac.com

PURAC sinteses, Brasil
Phone +55 21 203 2191
Fax +55 21 263 9288
E-mail: ppbr@purac.com

PURAC Japan, Japan
Phone +81 3 5720 7531
Fax +81 3 5720 7565
E-mail: ppjk@purac.com

http://www.purac.com

All rights reserved. No part of this publication may be copied, downloaded, reproduced, stored in a retrieval system or transmitted in any form by any means, electronic, mechanical, photocopied, recorded or otherwise, without permission of the publisher. No representation or warranty is made as to the truth or accuracy of any of the data, information or opinions contained herein or as to their suitability for any purpose, condition or application. None of the data, information or opinions contained herein may be relied upon for any purpose or reason. PURAC disclaims any liability, damages, losses or other consequences suffered or incurred in connection with the use of the data, information or opinions contained herein.

Printed in the Netherlands 09-'99/E