(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199943467 B2
(10) Patent No. 758625

(54) Title
The treatment of meat products

(51)[6] International Patent Classification(s)
A23L 001/31 A23L 003/3508
A23B 004/20

(21) Application No: 199943467 (22) Application Date: 1999.08.09

(30) Priority Data

(31) Number	(32) Date	(33) Country
09/137242	1998.08.20	US
09/368452	1999.08.03	US

(43) Publication Date : 2000.03.09
(43) Publication Journal Date : 2000.03.09
(44) Accepted Journal Date : 2003.03.27

(71) Applicant(s)
Ecolab Inc.

(72) Inventor(s)
Timothy A Gutzmann; Brian J Anderson; Pamela J Reed ; Bruce R Cords; Lawrence A Grab; Edward H Richardson

(74) Agent/Attorney
GRIFFITH HACK,GPO Box 1285K,MELBOURNE VIC 3001

(56) Related Art
US 5683724
US 3934044
US 5632676

Abstract

Described is a method of sanitizing meat product using aqueous streams having an antimicrobial composition added to the stream. Preferably, the antimicrobial composition includes a mixture of one or more carboxylic acids having up to 18 carbon atoms and one or more peroxycarboxylic acids having up to 12 carbon atoms, preferably a mixture of a C_2-C_4 peroxycarboxylic acid and a C_8-C_{12} peroxycarboxylic acid. Also described is a novel antimicrobial composition adapted for sanitizing meat product containing a mixture of one or more C_2-C_4 peroxycarboxylic acids and one or more C_8-C_{12} peroxycarboxylic acids and an alpha-hydroxy mono- or dicarboxylic acid.

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

STANDARD PATENT

Applicant:

ECOLAB INC.

Invention Title:

THE TREATMENT OF MEAT PRODUCTS.

The following statement is a full description of this invention, including the best method of performing it known to me/us:

THE TREATMENT OF MEAT PRODUCTS

Field of the Invention

This invention generally relates to compositions and processes for cleaning or sanitizing meat product during meat packing or preparation. More specifically, this invention relates to antimicrobial compositions and processes for cleaning and sanitizing meat product through direct contact between the meat product and the treatment. The nature of the contact between the meat product and the antimicrobial compositions improves antimicrobial properties. The compositions and methods reduce microbial populations and do not affect the appearance, smell or taste of the meat product.

Background of the Invention

The cleaning of meat product in the preparation of any food product can be an unsanitary and time consuming task. Further, without a cleaning routine which follows an ordered process of steps to completely sanitize meat product, any number of problems may arise. Meat product may retain pathogens or infectious microbes (*E. coli*) or become increasingly more contaminated if viscera is allowed to rupture or is not properly removed. Further, incomplete cleaning of the meat product may also result in the presence of infectious microbes making the meat unsuitable for consumption.

PURAC® is a natural lactic acid produced by fermentation from sugar. It has a mild acid taste and is widely used in the food industry as an acidulant. PURAC® is an effective decontaminating agent for use with poultry, beef and pork carcasses and slaughter by-products. PURAC® is most effective at a use concentration of between 1 and 2 percent, and can be used at several different points in the slaughter line. Application immediately after hide removal reduces the amount of microorganisms entering subsequent processing steps, while treatments after evisceration and prior to chilling have the greatest residual effects. Mountney et al. also discuss the use of lactic acid to lower bacterial counts and otherwise preserve poultry in "Acids As Poultry Meat Preservatives" in Poultry Science, 44: 582, 1965. Blankenship et al. discussed the destruction of Salmonella contaminates on fajita chicken meat in

"Efficacy of Acid Treatment Plus Freezing To Destroy Salmonella Contaminates Of Spice Coated Chicken Fajita Meat" in Poultry Science,, Vol. 69, Supp., 1990, p. 20. Adams et al. discuss the use of propylene glycol, sodium lactate, and lactic acid in chill water to reduce salmonella contamination of processed broilers. (See, Effects of Various Chill Water Treatments on Incidents and Levels of Salmonella on Processed Carcasses, Department of Animal and Poultry Sciences, University of Arkansas, Fayetteville). Izat et al. discuss the effects of lactic acid on commercial broiler carcasses in reducing salmonella counts in Poultry Science, Vol. 69, Supp. 1990, p. 152; Journal of Quality, Vol. 13, 1990 p. 295-306; and Journal of Food Protection, Vol. 52, No. 9, pp. 670-673, Sept. 1989. Avens et al. discuss the pasteurization of turkey carcasses and the reduction of salmonella using lactic acid in Poultry Science, Vol. 51, 1972, p. 1781. Mulder et al. in 1987 Poultry Science 66:1555-1557 reports a study of treating broiler carcasses with lactic acid, l-cysteine and hydrogen peroxide. The treatment with lactic acid and hydrogen peroxide resulted in a 4-log cycle reduction in colony forming units of *Salmonella typhimurium*. Nevertheless, use of lactic acid resulted in a slightly changed color of the carcasses and all the treatments with hydrogen peroxide resulted in bleached and bloated carcasses.

Although peroxycarboxylic acids are known to be used for cleaning and sanitizing equipment and other surfaces, they have not been reported for cleaning and sanitizing meat product. Holzhauer et al., U.S. Patent 5,435,808, describes curing of animal hides with an acetic acid, peroxyacetic acid, hydrogen peroxide, and phosphoric acid combination. The heightened concerns of consumers over the organoleptic purity and safety of meat products, concerns over the environmental and organoleptic impact of many antimicrobial agents currently available, as well as the stringent economies of the meat and poultry industry have resulted in an ongoing need for meat product sanitizing compositions and processes which provide increased sanitization with organoleptic and environmental purity.

AUSTRALIAN PATENT OFFICE

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a method of treating a meat product to reduce a microbial population in the meat product, the method including the steps of:

(a) treating said meat product with an antimicrobial composition including:

(i) an effective antimicrobial amount including at least 2 ppm of one or more mono- or di-peroxycarboxylic acids having up to 12 carbon atoms; and

(ii) an effective antimicrobial amount including at least 20 ppm of one or more carboxylic acids having up to 18 carbon atoms; and

(b) reducing the microbial population.

Preferably, the method of treating meat product obtains a reduction in surface microbial population by at least one $\log_{10}$, which method includes the step of treating said meat product with an

AUSTRALIAN PATENT OFFICE

antimicrobial composition comprising an effective antimicrobial amount comprising at least 2 parts per million (ppm, parts by weight per each one million parts) of one or more peroxycarboxylic acids having up to 12 carbon atoms and an effective antimicrobial amount comprising at least 20 ppm of one or more carboxylic acids having up to 18 carbon atoms to reduce the microbial population.

A second aspect of the invention is an antimicrobial composition adapted for cleaning and sanitizing meat product which contains about 0.5 weight percent (wt-%) to about 20 wt-% of a mixture of one or more peroxycarboxylic acids having from 2-4 carbon atoms, and one or more peroxycarboxylic acids having from 8-12 carbon atoms, from about 0.5 wt-% to about 60 wt-% of an alpha-hydroxy mono or dicarboxylic acid having 3-6 carbon atoms, an effective amount of a sequestrant and an effective amount of a hydrotrope.

A third preferred aspect of the present invention is an antimicrobial composition adapted for treating meat product consisting of a mixture of peroxyacetic and peroxyoctanoic acid in a ratio of about 10:1 to about 1:1, from about 0.1 to about 10 wt-% of lactic acid, from about 4 wt-% to about 10 wt-% of hydrogen peroxide and from about 0.5 wt-% to about 1.5 wt-% of a sequestering agent.

A fourth aspect of the present invention involves a method of treating a meat product to reduce a microbial population in the meat product, the method comprising the steps of spraying an aqueous antimicrobial treatment composition onto said meat product at a pressure of at least 50 psi at a temperature of up to about 60°C resulting in a contact time of at least 30 seconds, the antimicrobial composition comprising an effective antimicrobial amount comprising least 2 ppm of one or more carboxylic acid, peroxycarboxylic acid or mixtures thereof; and achieving at least a one $\log_{10}$ reduction in the microbial population.

A fifth aspect of the present invention involves a method of treating an meat product to reduce a microbial population in the meat product, the method comprising the steps of placing the meat product in a chamber at atmospheric pressure; filling the chamber with condensing steam comprising an antimicrobial composition for a short duration; and quickly venting and cooling the chamber to prevent browning of the meat product; wherein the duration of the steam thermal process may be from

about 5 seconds to about 30 seconds and the chamber temperature may reach from about 50 °C to about 93°C.

The antimicrobial composition can be applied in various ways to obtain intimate contact with each potential place of microbial contamination. For example, it can be sprayed on the meat product, or the meat product can be immersed in the composition. Additional methods include applying a foamed composition and a thickened or gelled composition. Vacuum and or light treatments can be included, if desired, with the application of the antimicrobial composition. Thermal treatment can also be applied, either pre-, concurrent with or post application of the antimicrobial composition. We have found a preferred spray method for treating meat product with compositions of the invention involving spraying the meat product with an aqueous spray at a temperature less than about 60°C at a pressure of about 50 to 500 psi gauge wherein the spray comprises an effective antimicrobial amount of a carboxylic acid, an effective antimicrobial amount of a peroxycarboxylic acid or mixtures thereof. These sprays can also contain an effective portion of a peroxy compound such as hydrogen peroxide and other ingredients such as sequestering agents, etc. We have found that the high pressure spray action of the aqueous treatment removes microbial populations by combining the mechanical action of the spray with the chemical action of the antimicrobial materials to result in a surprisingly improved reduction of such populations on the surface of the meat product. All pressures are psig (or psi gauge). Differentiation of antimicrobial "-cidal" or "-static" activity, the definitions which describe the degree of efficacy, and the official laboratory protocols for measuring this efficacy are important considerations for understanding the relevance of antimicrobial agents in compositions. Antimicrobial compositions may effect two kinds of microbial cell damages. The first is a truly lethal, irreversible action resulting in complete microbial cell destruction or incapacitation. The second type of cell damage is reversible, such that if the organism is rendered free of the agent, it can again multiply. The former is termed bacteriocidal and the latter, bacteriostatic. A sanitizer and a disinfectant are, by definition, agents which provide antibacterial or bacteriocidal activity and achieve at least a five fold reduction (i.e., a five log10

reduction) in microbial populations after a 30 second contact time (see AOAC method 960.09).

In contrast, a preservative is generally described as an inhibitor or bacteriostatic composition that simply retards growth in a reversible mode. For the purpose of this patent application, successful microbial reduction is achieved when the microbial populations are reduced by one $\log_{10}$. In this industry, the one $\log_{10}$ microbial population reduction is the minimum acceptable for the processes. Any increased reduction in microbial population is an added benefit that provides higher levels of protection for processed meat product.

Detailed Description of the Invention

The invention is a process for sanitizing meat product through treatment with aqueous streams containing an antimicrobial composition. The dip or spray methods used for meat product cleaning as well as sanitizing meat product generally include an effective antimicrobial concentration of one or more carboxylic acids and one or more peroxycarboxylic acids.

The term "meat product" encompasses all forms of animal flesh. The flesh of animals includes muscle, fat, organs, skin, bones and body fluids and like components that form the animal. Animal flesh includes the flesh of mammals, birds, fishes, reptiles, amphibians, snails, clams, crustaceans, or other edible species such as lobster, crab, etc. The forms of animal flesh include, for example, the whole or part of animal flesh, alone or in combination with other ingredients. Typical forms include, for example, processed meats such as cured meats, sectioned and formed products, minced products, finely chopped products and whole products.

A. The Sanitizing Composition

The sanitizing composition used in the method of the invention generally contains one or more carboxylic acids and one or more peroxycarboxylic acids with a peroxygen compound such as H_2O_2. Typically, however, the composition contains one or more carboxylic acids, an oxidizer, and one or more peroxycarboxylic acids depending on equilibrium. Commonly, the peroxycarboxylic acid material can be made by oxidizing a carboxylic acid directly to the peroxycarboxylic acid material

which is then solubilized in the aqueous rinse agent compositions of the invention. Further, the materials can be made by combining the unoxidized acid with a peroxygen compound such as hydrogen peroxide to generate the peracid in situ prior to blending the peroxycarboxylic acid with other constituents. The compositions of the invention comprises blends of the carboxylic acid and percarboxylic acid along with other components including a peroxy source such as hydrogen peroxide. Once blended and applied the compositions can change due to interactions between the blended materials and due to interactions in the use locus. For example, the salt component can exchange and become associated with free acids and the peroxy source can oxidize oxidizable materials. The anti-microbial properties arise from the blend of an acid material and a peracid material. The modification post blending and application do not change the invention.

A carboxylic acid is an organic acid (R-COOH) which contains an aliphatic group and one or more carboxyl groups. A carboxyl group is represented by -COOH, and is usually located at a terminal end of the acid. The aliphatic group can be a substituted or unsubstituted group. Common aliphatic substituents include -OH, -OR, -NO_2, halogen, and other substituents common on these groups. An example of a simple carboxylic acid is acetic acid, which has the formula CH_3COOH. A peroxycarboxylic acid is a carboxylic acid which has been oxidized to contain a terminal -COOOH group. The term peroxy acid is often used to represent a peroxycarboxylic acid. An example of a simple peroxy acid is peroxyacetic acid, which has the formula CH_3COOOH.

Generally when the peroxycarboxylic acid is formulated in accordance with the invention a monocarboxylic acid, such as acetic acid, is combined with an oxidizer such as hydrogen peroxide. The result of this combination is a reaction producing a peroxycarboxylic acid, such as peroxyacetic acid, and water. The reaction follows an equilibrium in accordance with the following equation:

$$H_2O_2 + CH_3COOH \rightleftharpoons CH_3COOOH + H_2O$$

wherein the pK_{eq} is 1.7.

The importance of the equilibrium results from the presence of hydrogen peroxide, the carboxylic acid and the peroxycarboxylic acid in the same composition at the same time. Because of this equilibrium, a mixture of carboxylic acid and peroxycarboxylic acid can be combined in water without adding hydrogen peroxide. If permitted to approach equilibrium, the mixture will evolve hydrogen peroxide. This combination provides enhanced sanitizing with none of the deleterious environmental or organoleptic effects of other sanitizing agents, additives, or compositions.

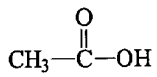
THE CARBOXYLIC ACID

The first constituent of the composition used in the method of the invention includes one or more carboxylic acids. Generally, carboxylic acids have the formula R-COOH wherein the R may represent any number of different groups including aliphatic groups, alicyclic groups, aromatic groups, heterocyclic groups, all of which may be saturated or unsaturated. Carboxylic acids also occur having one, two, three, or more carboxyl groups. Aliphatic groups can be further differentiated into three distinct classes of hydrocarbons. Alkanes (or paraffins) are saturated hydrocarbons. Alkenes (or olefins) are unsaturated hydrocarbons which contain one or more double bonds and alkynes (or acetylenes) are unsaturated hydrocarbons containing one or more highly reactive triple bonds. Alicyclic groups can be further differentiated into three distinct classes of cyclic hydrocarbons. Cycloparaffins are saturated cyclic hydrocarbons. Cycloolefins are unsaturated cyclic hydrocarbons which contain one or more double bonds while cycloacetylenes are unsaturated cyclic hydrocarbons containing one or more highly reactive triple bonds. Aromatic groups are defined as possessing the unsaturated hydrocarbon ring structure representative of benzene. Heterocyclic groups are defined as 5 or 6 member ring structures wherein one or more of the ring atoms are not carbon. An example is pyridine, which is essentially a benzene ring with one carbon atom replaced with a nitrogen atom.

Carboxylic acids have a tendency to acidify aqueous compositions in which they are present as the hydrogen atom of the carboxyl group is active and may appear as a cation. The carboxylic acid constituent within the present composition

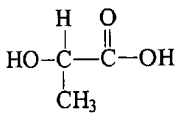
when combined with aqueous hydrogen peroxide generally functions as an antimicrobial agent as a result of the presence of the active hydrogen atom. Moreover, the carboxylic acid constituent within the invention maintains the composition at an acidic pH. The composition of the invention can utilize carboxylic acids containing as many as 18 carbon atoms. Examples of suitable carboxylic acids include formic, acetic, propionic, butanoic, pentanoic, hexanoic, heptanoic, octanoic, nonanoic, decanoic, undecanoic, dodecanoic, lactic, maleic, ascorbic, citric, hydroxyacetic, neopentanoic, neoheptanoic, neodecanoic, oxalic, malonic, succinic, glutaric, adipic, pimelic and subric acid.

Carboxylic acids which are generally useful are those having one or two carboxyl groups where the R group is a primary alkyl chain having a length of C_2 to C_5 and which are freely water soluble. The primary alkyl chain is that carbon chain of the molecule having the greatest length of carbon atoms and directly appending carboxyl functional groups. Especially useful are mono- and dihydroxy substituted carboxylic acids including alpha-hydroxy substituted carboxylic acid. A preferred carboxylic acid is acetic acid, which produces peroxyacetic acid to increase the sanitizing effectiveness of the materials. Acetic acid has the structure of the formula:



An especially preferred α-hydroxy-monocarboxylic acid is lactic acid, also known as 2-hydroxypropionic acid, which is a naturally occurring organic acid. Lactic acid has a molecular weight of 90.08 and is soluble in water, alcohol, acetone, ether and glycerol. Lactic acid occurs naturally and may be produced by fermentation. Alternatively, lactic acid may be synthesized.

Lactic acid has the structure of the formula



The concentration of α-hydroxy-mono-or di-carboxylic acid useful in the present invention generally ranges from about 0.5 wt-% to about 60 wt-%, preferably about 1 wt-% to about 20 wt-%, and most preferably from about 2 wt-% to about 10 wt-%. This concentration range of lactic acid is preferred for reasons of optimal acidity within the composition, as well as for the optimal antimicrobial efficacy which it brings to the antimicrobial system.

Reducing the concentration of lactic acid in comparison to any given concentration of hydrogen peroxide will essentially reduce the antimicrobial activity of the composition. Moreover, reducing the concentration of lactic acid may result in an increase in the pH of the composition and accordingly raise the potential for decreased antimicrobial activity. In sharp contrast, increasing the concentration of lactic acid within the present composition may tend to increase the antimicrobial activity of the composition. Furthermore, increasing the concentration of lactic acid in the composition of the present invention will tend to decrease the pH of the composition. Preferably, the pH of the present composition will be 4 or less with a generally preferred pH in the composition being between 1.5 and 3.75, and a pH between about 2 and 3.5 being most preferred.

Generally, the concentration of carboxylic acid within the composition used in the process of the invention ranges from about 0.5 wt-% to about 60 wt-%, preferably from about 10 wt-% to about 60 wt-%, and most preferably from about 20 wt-% to about 50 wt-%.

THE PEROXYCARBOXYLIC ACID

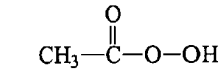
Another principle component of the antimicrobial composition of the invention is an oxidized carboxylic acid. This oxidized or peroxycarboxylic acid provides heightened antimicrobial efficacy when combined with hydrogen peroxide and the monocarboxylic acid in an equilibrium reaction mixture. Peroxycarboxylic acids generally have the formula $R(CO_3H)_n$, where R is an alkyl, arylalkyl,

cycloalkyl, aromatic or heterocyclic group, and n is one or two and named by prefixing the parent acid with peroxy. An alkyl group is a paraffinic hydrocarbon group which is derived from an alkane by removing one hydrogen from the formula. The hydrocarbon group may be either linear or branched, having up to 12 carbon atoms. Simple examples include methyl (CH_3) and ethyl (CH_2CH_3). An arylalkyl group contains both aliphatic and aromatic structures. A cycloalkyl group is defined as a cyclic alkyl group.

While peroxycarboxylic acids are not very stable, their stability generally increases with increasing molecular weight. Thermal decomposition of these acids may generally proceed by free radical and nonradical paths, by photodecomposition or radical-induced decomposition, or by the action of metal ions or complexes. Peroxycarboxylic acids may be made by the direct, acid catalyzed equilibrium action of 30-98 wt-% hydrogen peroxide with the carboxylic acid, by autoxidation of aldehydes, or from acid chlorides, acid anhydrides, or carboxylic anhydrides with hydrogen or sodium peroxide.

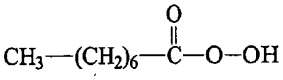
Peroxycarboxylic acids useful in this invention include peroxyformic, peroxyacetic, peroxypropionic, peroxybutanoic, peroxypentanoic, peroxyhexanoic, peroxyheptanoic, peroxyoctanoic, peroxynonanoic, peroxydecanoic, peroxyundecanoic, peroxydodecanoic, peroxylactic, peroxymaleic, peroxyascorbic, peroxyhydroxyacetic, peroxyoxalic, peroxymalonic, peroxysuccinic, peroxyglutaric, peroxyadipic, peroxypimelic and peroxysubric acid and mixtures thereof. These peroxycarboxylic acids have been found to provide good antimicrobial action with good stability in aqueous streams. In a preferred embodiment, the composition of the invention utilizes a combination of several different peroxycarboxylic acids. Preferably, the composition includes one or more small C_2-C_4 peroxycarboxylic acids and one or more large C_8-C_{12} peroxycarboxylic acids. Especially preferred is an embodiment in which the small peroxycarboxylic acid is peroxyacetic acid and the large acid is either peroxyoctanoic acid or peroxydecanoic acid.

Peroxyacetic acid is a peroxycarboxylic acid with a structure as given the formula:

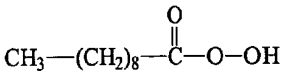


wherein the peroxy group ,-O-O- , is considered a high energy bond. Generally, peroxyacetic acid is a liquid having an acrid odor and is freely soluble in water, alcohol, ether, and sulfuric acid. Peroxyacetic acid may be prepared through any number of means known to those of skill in the art including preparation from acetaldehyde and oxygen in the presence of cobalt acetate. A 50% solution of peroxyacetic acid may be obtained by combining acetic anhydride, hydrogen peroxide and sulfuric acid. Other methods of formulation of peroxyacetic acid include those disclosed in U.S. Patent No. 2,833,813, which is incorporated herein by reference.

Peroxyoctanoic acid has the structure of the formula:



Peroxydecanoic acid has the structure of the formula:



The preferred peroxycarboxylic acid materials of the invention can be used to increase the sanitizing effectiveness of the materials. When a blended acid is used, the peroxycarboxylic acid is blended in proportions that range from about 10:1 to about 1:1 parts of C_2-C_4 peroxycarboxylic acid per part of C_8-C_{12} peroxycarboxylic acid. Preferably, peroxyacetic acid is used at a ratio of about 8 parts per part of peroxyoctanoic acid.

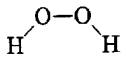
The above sanitizer material can provide antibacterial activity to the rinse aid sanitizers of the invention against a wide variety of microorganisms such as gram positive (for example, *Staphylococcus aureus*) and gram negative (for example, *Escherichia coli*) microorganisms, yeast, molds, bacterial spores, viruses, etc. When

combined, the above peroxy acids can have enhanced activity compared to the low molecular weight peroxy acids alone.

Generally, the concentration of peroxycarboxylic acid within the composition used in the process of the invention ranges from about 0.5 wt-% to about 20 wt-%, preferably from about 2 wt-% to about 15 wt-%, and most preferably from about 4 wt-% to about 12 wt-%.

THE OXIDIZER

The composition used in the method of the invention also includes an oxidizer. Any number of oxidizers may be used as a precursor to the formation of a peroxycarboxylic acid as well as to provide further physical effervescent or agitation action to the composition of the invention. Preferably, the antimicrobial composition of the invention contains hydrogen peroxide. Hydrogen peroxide (H_2O_2) has a molecular weight of 34.014 and it is a weakly acidic, clear, colorless liquid. The four atoms are covalently bonded in a non-polar structure:



Generally, hydrogen peroxide has a melting point of -0.41°C, a boiling point of 150.2°C, a density at 25°C of 1.4425 grams per cm^3, and a viscosity of 1.245 centipoise at 20°C.

Hydrogen peroxide in combination with the carboxylic acid and peroxycarboxylic acid provides a surprising level of antimicrobial action against microorganisms, even in the presence of high loadings of organic sediment. Additionally, hydrogen peroxide provides an effervescent action which may irrigate any surface to which it is applied. Hydrogen peroxide works with a mechanical flushing action once applied which further plains the surface of application. An additional advantage of hydrogen peroxide is the food compatibility of this composition upon use and decomposition. For example, combinations of peroxyacetic acid and hydrogen peroxide result in acetic acid, water, and oxygen upon decomposition. All of these constituents are food product compatible. Generally, the concentration of hydrogen peroxide within the composition used in

the process of the invention ranges from about 1 wt-% to about 35 wt-%, preferably from about 2 wt-% to about 25 wt-%, and most preferably from about 5 wt-% to about 10 wt-%. This concentration of hydrogen peroxide is most preferred as providing optimal antimicrobial effect.

These concentrations of hydrogen peroxide may be increased or decreased while still remaining within the scope of the present invention. For example, increasing the concentration of hydrogen peroxide may increase the antimicrobial efficacy of the claimed invention. Furthermore, increasing the hydrogen peroxide concentration may reduce the need to stabilize the hydrogen peroxide within the composition. Specifically, increasing the hydrogen peroxide concentration in the composition may provide a composition which has extended shelf life.

In contrast, decreasing the concentration of hydrogen peroxide may decrease the antimicrobial efficacy of the composition and necessitate the use of an increased concentration of carboxylic acid. Moreover, decreasing the concentration of hydrogen peroxide may necessitate the use of some stabilizing agent to ensure that the composition of the present invention will remain stable and efficacious over the intended time period.

In all, altering the concentration of the oxidizing agent will effect the equilibrium mix of the peroxycarboxylic acid used in the invention.

THE CARRIER

The composition of the invention also includes a carrier. The carrier functions to provide a reaction medium for the solubilization of constituents and the production of peroxycarboxylic acid as well as a medium for the development of an equilibrium mixture of oxidizer, peroxycarboxylic acid, and carboxylic acid. The carrier also functions to deliver and wet the antimicrobial composition of the invention to the intended substrate. To this end, the carrier may contain any component or components which will facilitate the functions. Generally, the carrier consists of water which is an excellent solubilizer and medium for reaction and equilibrium. The carrier may also include any number of constituents such as various organic compounds which facilitate the functions provided above. Organic solvents which have been found useful include simple alkyl alcohols such as

ethanol, isopropanol, n-propanol, and the like. Polyols are also useful carriers in accordance with the invention, including propylene glycol, polyethyleneglycol, glycerol, sorbitol, and the like. Any of these compounds may be used singly or in combination with other organic or inorganic constituents or, in combination with water or in mixtures thereof. Preferably, the carrier consists of from about 1 wt-% to about 60 wt-% of an organic solvent.

Generally, the carrier makes up a large portion of the composition of the invention and may essentially be the balance of the composition apart from the active antimicrobial composition adjuvants, and the like. Here again, the carrier concentration and type will depend upon the nature of the composition as a whole, the environmental storage and method of application including concentration of the antimicrobial agent, among other factors. Notably the carrier should be chosen and used at a concentration which does not inhibit the antimicrobial efficacy of the act in the composition of the invention.

B. Adjuvants

The composition of the invention may also optionally include any number of adjuvants which are stable in an oxidizing environment, and add beneficial properties of stability, sequestration, sheeting and rinsing, etc. These adjuvants may be preformulated with the sanitizing agent of the invention or added to the system simultaneously, or even after, the addition of the sanitizing agent of the invention.

Chelating Agent

The sanitizing agents of the invention may also contain a polyvalent metal complexing or chelating agent that aids in reducing the harmful effects of hardness components and service water and improves product stability. The typically harmful effects of calcium, magnesium, iron, manganese, etc., ions present in service water can interfere with the action of either the washing compositions or rinsing compositions or can tend to decompose the active peroxygen sanitizer materials. The chelating agent or sequestering agent can effectively complex and remove such ions from inappropriate interaction with active ingredients thus increasing sanitizing agent performance.

Both organic and inorganic chelating agents may be used. Inorganic chelating agents include such compounds as sodium tripolyphosphate and other higher linear and cyclic polyphosphate species. Organic chelating agents include both polymeric and small molecule chelating agents. Polymeric chelating agents commonly comprise polyanionic compositions such as polyacrylic acid compounds. Amino phosphates and phosphonates are also suitable for use as chelating agents in the compositions of the invention and include ethylene diamine (tetramethylene phosphonates), nitrilotrismethylene phosphates, diethylenetriamine (pentamethylene phosphonates). These amino phosphonates commonly contain alkyl or alkaline groups with less than 8 carbon atoms.

Preferred chelating agents for use in this invention include improved food additive chelating agents such as disodium salts of ethylene diamine tetraacetic acid or the well known phosphonates sold in the form of DEQUEST® materials, for example, 1-hydroxyethylidene-l,l-diphosphonic acid, etc. The phosphonic acid may also comprise a low molecular weight phosphonopolycarboxylic acid such as one having about 2-4 carboxylic acid moieties and about 1-3 phosphonic acid groups. Such acids include 1-phosphono-l-methylsuccinic acid, phosphonosuccinic acid and 2-phosphonobutane-1,2,4-tricarboxylic acid. Another organic phosphonic acid is $(CH_3C(PO_3H_2)_2OH)$, available from Monsanto Industrial Chemicals Co., St. Louis, MO, as DEQUEST® 2010, (which is a 58-62% aqueous solution; amino (tri(methylenephosphonic acid)] $(N[CH_2PO_3H_2]_3)$, available from Monsanto as DEQUEST® 2000, as a 50% aqueous solution; ethylenediamine [tetra(methylenephosphonic acid)] available from Monsanto as DEQUEST® 2041, as a 90% solid acid product; and 2-phosphonobutane-1,2,4-tricarboxylic acid available from Mobay Chemical Corporation, Inorganic Chemicals Division, Pittsburgh, PA, as Bayhibit AM, as a 45-50% aqueous solution.

The above-mentioned phosphonic acids can also be used in the form of water soluble acid salts, particularly the alkali metal salts, such as sodium or potassium; the ammonium salts or the alkylol amine salts where the alkylol has 2 to 3 carbon atoms, such as mono-, di-, or triethanolamine salts. If desired, mixtures of the individual phosphonic acids or their acid salts can also be used.

The concentration of chelating agent useful in the present invention generally ranges from about 0.01 to about 10 wt-%, preferably from about 0.1 to about 5 wt-%, most preferably from about 0.5 to about 2 wt-%.

Hydrotrope

The sanitizing agent of the invention may also include a hydrotrope coupler or solubilizer. Such materials can be used to ensure that the composition remains phase stable and in a single highly active aqueous form. Such hydrotrope solubilizers or couplers can be used at compositions which maintain phase stability but do not result in unwanted compositional interaction.

Representative classes of hydrotrope solubilizers or coupling agents include an anionic surfactant such as an alkyl sulfate, an alkyl or alkane sulfonate, a linear alkyl benzene or naphthalene sulfonate, a secondary alkane sulfonate, alkyl ether sulfate or sulfonate, an alkyl phosphate or phosphonate, dialkyl sulfosuccinic acid ester, sugar esters (e.g., sorbitan esters) and a C_{8-10} alkyl glucoside.

Preferred coupling agents for use in the rinse agents of the invention include n-octane sulfonate and aromatic sulfonates such as an alkyl benzene sulfonate (e.g., sodium xylene sulfonate or naphthalene sulfonate). Many hydrotrope solubilizers independently exhibit some degree of antimicrobial activity at low pH. Such action adds to the efficacy of the invention but is not a primary criterion used in selecting an appropriate solubilizing agent. Since the presence of the peroxycarboxylic acid material in the proteinated neutral state provides beneficial biocidal or sanitizing activity, the coupling agent should be selected not for its independent antimicrobial activity but for its ability to provide effective single phase composition stability in the presence of substantially insoluble peroxycarboxylic acid materials and the more soluble compositions of the invention.

Generally, any number of surfactants may be used consistent with the purpose of this constituent.

Anionic surfactants useful with the invention include alkyl carboxylates, linear alkylbenzene sulfonates, paraffin sulfonates and secondary n-alkane sulfonates, sulfosuccinate esters and sulfated linear alcohols.

Zwitterionic or amphoteric surfactants useful with the invention include β-N-alkylaminopropionic acids, n-alkyl-β-iminodipropionic acids, imidazoline carboxylates, n-alky-Iletaines, amine oxides, sulfobetaines and sultaines.

Nonionic surfactants useful in the context of this invention are generally polyether (also known as polyalkylene oxide, polyoxyalkylene or polyalkylene glycol) compounds. More particularly, the polyether compounds are generally polyoxypropylene or polyoxyethylene glycol compounds. Typically, the surfactants useful in the context of this invention are synthetic organic polyoxypropylene (PO)-polyoxyethylene (EO) block copolymers. These surfactants have a diblock polymer comprising an EO block and a PO block, a center block of polyoxypropylene units (PO), and having blocks of polyoxyethylene grated onto the polyoxypropylene unit or a center block of EO with attached PO blocks. Further, this surfactant can have further blocks of either polyoxyethylene or polyoxypropylene in the molecule. The average molecular weight of useful surfactants ranges from about 1000 to about 40,000 and the weight percent content of ethylene oxide ranges from about 10-80% by weight.

Also useful in the context of this invention are surfactants including alcohol alkoxylates having EO, PO and BO blocks. Straight chain primary aliphatic alcohol alkoxylates can be particularly useful as sheeting agents. Such alkoxylates are also available from several sources including BASF Wyandotte where they are known as "Plurafac" surfactants. A particular group of alcohol alkoxylates found to be useful are those having the general formula $R\text{-}(EO)_m\text{--}(PO)_n$ wherein m is an integer of about 2-10 and n is an integer from about 2-20. R can be any suitable radical such as a straight chain alkyl group having from about 6-20 carbon atoms.

Other useful nonionic surfactants of the invention include capped aliphatic alcohol alkoxylates. These end caps include but are not limited to methyl, ethyl, propyl, butyl, benzyl and chlorine. Preferably, such surfactants have a molecular

weight of about 400 to 10,000. Capping improves the compatibility between the nonionic and the oxidizers hydrogen peroxide and peroxycarboxylic acid, when formulated into a single composition. Other useful nonionic surfactants are alkylpolyglycosides.

Another useful nonionic surfactant of the invention is a fatty acid alkoxylate wherein the surfactant comprises a fatty acid moiety with an ester group comprising a block of EO, a block of PO or a mixed block or heteric group. The molecular weights of such surfactants range from about 400 to about 10,000, a preferred surfactant has an EO content of about 30 to 50 wt-% and wherein the fatty acid moiety contains from about 8 to about 18 carbon atoms.

Similarly, alkyl phenol alkoxylates have also been found useful in the invention. Such surfactants can be made from an alkyl phenol moiety having an alkyl group with 4 to about 18 carbon atoms, can contain an ethylene oxide block, a propylene oxide block or a mixed ethylene oxide, propylene oxide block or heteric polymer moiety. Preferably such surfactants have a molecular weight of about 400 to about 10,000 and have from about 5 to about 20 units of ethylene oxide, propylene oxide or mixtures thereof.

The concentration of hydrotrope useful in the present invention generally ranges from about 0.1 to about 20 wt-%, preferably from about 0.5 to about 10 wt-%, most preferably from about 1 to about 4 wt-%.

Thickening/Gelling Agents

Thickeners useful in the present invention are those which do not leave contaminating residue on the surface of application, i.e., constituents which are incompatible with food or other sensitive products in contact areas.

Generally, thickeners which may be used in the present invention include natural gums such as xanthan gum. Also useful in the present invention are cellulosic polymers, such as carboxymethyl cellulose. Generally, the concentration of thickener use in the present invention will be dictated by the desired viscosity within the final composition. However, as a general guideline, viscosity of thickener within the present composition ranges from about 0.1 wt-% to about 1.5 wt-%,

preferably from about 0.1 wt-% to about 1.0 wt-%, and most preferably from about 0.1 wt-% to about 0.5 wt-%.

C. Formulation

The compositions of the invention can be formulated by combining the sanitizing agent materials including other adjuvant components with the materials that form the sanitizer composition, the carboxylic acid or acid blend, hydrogen peroxide and optionally, hydrotrope solubilizer.

The compositions can also be formulated with preformed peroxycarboxylic acids. The preferred compositions of the invention can be made by mixing the carboxylic acid or mixture thereof with an optional hydrotrope solubilizer or coupler, reacting the mixture with hydrogen peroxide and then adding the balance of required ingredients to provide rinsing and sanitizing action.

A stable equilibrium mixture is produced containing the carboxylic acid or blend with hydrogen peroxide and allowing the mixture to stand for 1-7 days at 15°C or more. With this preparatory method, an equilibrium mixture will be formed containing an amount of hydrogen peroxide, unoxidized acid, oxidized or peroxycarboxylic acid and typically unmodified couplers, solubilizer, or stabilizers.

D. Use Compositions

The invention contemplates a concentrate composition which is diluted to a use solution prior to its utilization as a sanitizer. Primarily for reasons of economics, the concentrate would normally be marketed and an end user would preferably dilute the concentrate with water or an aqueous diluent to a use solution.

The general constituent concentrations of the sanitizing concentrate formulated in accordance with the invention may be found in Table 1:

Table 1

Constituent	Preferred (wt-%)	More Preferred (wt-%)	Most Preferred (wt-%)
H_2O_2	1-35	2-25	5-10
Peroxycarboxylic acids	0.5-20	2-15	4-12
Carboxylic acid	0.5-60	10-60	20-50
Chelating agent	0.01-10	0.01-5	0.5-2
Hydrotrope	0.1-20	0.5-10	1-4
Thickening agent	0.1-1.5	0.1-1.0	0.1-0.5
Carrier	0-97	10-90	12-65

The level of active components in the concentrate composition is dependent on the intended dilution factor and the desired activity of the peroxycarboxylic acid compound and the carboxylic acid.

Generally, a dilution of about 1 fluid ounce to about 0.5 to 10.0 gallons of water is used for aqueous antimicrobial sanitizing solutions. The composition shown in the preferred column of the Table 1 above would be used in a range from about 12.8 fluid ounce per gallon water to about 1 fluid ounce per 780 gallons of water depending on the desired level of peroxycarboxylic acid and concentration of the peroxycarboxylic acid in the product concentrate.

Higher use dilutions can be employed if elevated use temperature (greater than 25°C) or extended exposure time (greater than 30 seconds) can be employed. In the typical use locus, the concentrate is diluted with a major proportion of water and used for sanitizing using commonly available tap or service water mixing the materials at a dilution ratio of about 0.1 to about 2 ounces of concentrate per gallon of water.

Aqueous antimicrobial sanitizing use solutions can include at least about 2 ppm, preferably about 10 to about 500 ppm, and more preferably about 100 to about 250 parts per million of the peroxycarboxylic acid material; about 20 ppm to about 10,000 ppm, and preferably about 50 ppm to about 1,000 ppm of carboxylic acid; and about 10 to about 1,000 ppm of hydrogen peroxide. The aqueous use solution can further include at least about 50 ppm, preferably about 500 ppm of the

hydrotrope solubilizer, and have a pH in the use solution in the range of about 1 to about 11 preferably about 2 to about 10.

E. Method of Use

During processing of the meat product, the meat product can be contacted with the compositions of the invention in any mode be that insures good contact between the meat product and the composition and at least some minimal mechanical work to result in at least a one $\log_{10}$ reduction , preferably at least a two $\log_{10}$ reduction and more preferably a three $\log_{10}$ reduction in the resident microbial preparation. A five $\log_{10}$ reduction in 30 seconds is a sanitizing treatment.

The invention is applicable to a wide range of meat product. For example, the antimicrobial compositions of the invention can be used on muscle meats, or any portion thereof, of any animal. The muscle meats most commonly consumed included, for example, beef, pork, veal, buffalo or lamb, sea food including scallops, shrimp, crab, octopus, mussels, squid or lobster and poultry including chicken, turkey, ostrich, game hen, squab or pheasant. The meat product may be in the form of whole, sectioned, processed, cooked or raw meats, such as, for example, hot dogs, cold cuts, sausage, meat cuts, hamburger, sushi and the like.

A preferred mode is a pressure spray with the sanitizing solution of the invention. During application of the spray solution on the meat product, the surface of the meat product can be moved with mechanical action, preferably agitated, rubbed, brushed, etc. Agitation may be by physical scrubbing of the meat product, through the action of the spray solution under pressure or by other means. The agitation increases the efficacy of the spray solution in killing micro-organisms, perhaps due to better exposure of the solution into the crevasses or small colonies containing the micro-organisms. The spray solution, before application, may also be heated to a temperature of about 15 to 20°C, preferably about 20 to 50°C to increase efficacy. After a sufficient amount of time to kill the micro-organisms on the meat product, the spray solution may be rinsed off the meat product.

Application of the material by spray means can be accomplished using a manual spray wand application, an automatic spray of meat product moving along a production line using multiple spray heads to ensure complete contact or other spray

means. One preferred automatic spray application involves the use of a spray booth. The spray booth substantially confines the sprayed composition to within the parameter of the booth. The production line moves the meat product through the entryway into the spray booth in which the meat product is sprayed on all its exterior surfaces with sprays within the booth. After a complete coverage of the material and drainage of the material from the meat product within the booth, the meat product can then exit the booth in a fully treated form. The spray booth can comprises steam jets that can be used to apply the antimicrobial compositions of the invention. These steam jets can be used in combination with cooling water to ensure that the treatment reaching the meat product surface is less than 65°C, preferably less than 60°C. The temperature of the spray on the meat product is important to ensure that the meat product is not substantially altered (cooked) by the temperature of the spray. The spray pattern can be virtually any useful spray pattern.

The spray can comprise a fogged material that leaves a fogging apparatus as a dispersion of fog particles in a continuous atmosphere. Such a spray has no defined pattern. The spray can have a pattern such as a conical spray in which the angle between the perimeter of the spray ranges from less than 180° to about 5°. Other spray patterns can also be useful. We have found that one preferred spray pattern involves a "fan" spray pattern in which the spray exits the spray head in a substantially planar form and the angle between the extent of the planar spray from edge to edge is about 20° or less, preferably about 15° or less. We have found that such a spray is preferred due to the increased mechanical action and efficiency of antimicrobial composition add on to the meat product. When such a narrow angle fan spray is used in a spray cabinet enclosure to treat the meat product, we have found that the optimum distance between the spray head and the meat product is less than about 100 centimeters, preferably about 20 to 80 centimeters, most preferably about 30 to 50 centimeters. Such a configuration efficiently transfers antimicrobial material to the meat product for efficient reduction of the microbial populations.

There are a number of parameters which need to be considered if spraying is the application method of choice. The first parameter to determine is the pressure at which the composition is sprayed onto the meat product. While spray pressures as low as about 25 psi (gauge) can be used with some valuable results, a higher spray

pressure, greater than about 25, 50, 100, 150 psi and more preferably greater than about 200 psi, are effective in reducing the microbial populations due to the mechanical action of the spray on the meat product surface and on the microbial population remaining on the surface of the meat product. The spray action is best at temperatures less than 65°C. While a composition comprising lactic acid has been found to be most effective at low pressure, it has been discovered that equal, if not greater antimicrobial efficacy can be obtained by eliminating the lactic acid and merely increasing the spray application pressure. Further, if increased spray pressures are used, the antimicrobial composition can be applied at lower temperatures, potentially resulting in substantial energy savings. Of course there appears to be a relationship between application spray duration and antimicrobial efficacy. While spray durations of as little as about 10 seconds can be used, it has been discovered that a preferred spray duration is from about 10 to about 30 seconds. Without wishing to be limited by theory, the increased antimicrobial efficacy resulting from the use of the higher spray pressures is believed to be due to an improvement in penetrating the surface of the meat product, particularly an increased ability to reach into creases and crevices on the surface of the meat product.

During processing of the meat product, the meat product may also be immersed into a tank containing a quantity of sanitizing solution. The sanitizing solution is preferably agitated to increase the efficacy of the solution and the speed in which the solution kills micro-organisms attached to the meat product. Agitation can be obtained through conventional means including through ultrasonic means, aeration by bubbling air through the solution or by mechanical means, such as strainers, paddles, brushes, or pump driven liquid jets. The sanitizing solution may also be heated to increase the efficacy of the solution in killing micro-organisms. It is preferable that the meat product be immersed in the sanitizing solution after the meat product have been eviscerated and before any cooling process such as a chiller tank or a chill water spray.

In another alternative embodiment of the present invention, the meat product may be treated with a foaming version of the composition. The foam may be prepared by mixing foaming surfactants with the sanitizing solution at time of use.

The foaming surfactants could be nonionic, anionic or cationic in nature. Examples of useful surfactant types include, but not limited to the following: alcohol ethoxylates, alcohol ethoxylate carboxylate, amine oxides, alkyl sulfates, alkyl ether sulfate, sulfonates, quaternary ammonium compounds, alkyl sarcosines, betaines and alkyl amides. The foaming surfactant is mixed at time of use with the sanitizing solution. Use solution levels of the foaming agents is from about 50 ppm to about 2.0 wt-%. At time of use, compressed air is injected into the mixture, then applied to the meat product surface through a foam application device such as a tank foamer or an aspirated wall mounted foamer.

In another alternative embodiment of the present invention, the meat product may be treated with a thickened or gelled version of the composition. In the thickened or gelled state the sanitizing solution remains in contact with the meat product surface for longer periods of time, thus increasing the antimicrobial efficacy. The thickened or gelled solution will also adhere to vertical surfaces. The composition or the sanitizing solution may be thickened or gelled using existing technologies such as: xantham gum, polymeric thickeners, cellulose thickeners or the like. Rod micelle forming systems such as amine oxides and anionic counter ions could also be used. The thickeners or gel forming agents can be used either in the concentrated product or mixing with the sanitizing solution, at time of use. Typical use levels of thickeners or gel agents range from about 100 ppm to about 10 wt-%.

In another alternative embodiment of the present invention, the meat product may be treated with an electrostatically charged spray of the sanitizing solution. The sanitizing solution can be spray applied as a charged droplets by using conventional electrostatic spray technologies including inductively charged methodologies. As charged droplets, the sanitizing solution will be attracted to opposite or differentially charged surfaces such as the surface of the meat product. As a result, more sanitizing solution will be applied to the meat product surface and less solution will miss the intended target, commonly called over-spray. The charged droplets will also provide an evenly distributed solution layer on the meat product surface. The charged droplet size will range from about 10 microns to about 500 microns.

In another alternative embodiment of the present invention, the meat product may be subjected to a vacuum treatment either before applying the sanitizing solution, during the application of the sanitizing solution or after applying the sanitizing solution. When the meat product is subjected to a vacuum treatment in conjunction with the application of the sanitizing solution, the penetration of the sanitizing solution into the meat product substructure is enhanced. As a result, antimicrobial efficacy is improved. The amount of vacuum utilized is from about 2 inches of Mercury ("Hg) to about 29 inches of Mercury ("Hg).

In another alternative embodiment of the present invention, the meat product may be subjected to an activating light source following application of the sanitizing solution. The activating light can improve the antimicrobial efficacy of the sanitizing solution. The light source can be ultraviolet, infrared or from the visible spectrum.

The antimicrobial or sanitizing step can optionally be combined with a thermal intervention process which occurs either before, during or after the application of the antimicrobial composition. The thermal intervention process may employ hot water or dry heat. In the case of a hot water thermal process, the meat product is enclosed in a chamber at atmospheric pressure. The chamber is filled with condensing steam (finely divided liquid water) for a short duration, quickly vented, then cooled to prevent browning of the meat product. The duration of the steam thermal process may be from about 5 seconds to about 30 seconds. The chamber temperature may reach from about 50 °C to about 93°C. Similarly with dry heat, the meat product is placed in a chamber into which heated air is directed. The air is heated from about 65°C to about 260°C. The meat product is allowed from about 5 to about 30 seconds contact time with the heated air, the chamber is vented and the meat product is cooled.

Working Examples

The invention will now be described in more detail by reference to the following working examples. The only proper construction of these examples is as nonlimiting, illustrative example showing various formulations, stabilities, and applications of the invention.

Test Formula #1

Material	Weight Percent
Deionized water	53.9
Mixed Peroxycarboxylic acids[1]	4.75
Hydrogen Peroxide	6.9
Acetic Acid	25.0
Octanoic Acid	3.5
Hydroxyethylidene-1,1-diphosphonic acid	0.95
Sodium Octane mixed Mono- and Di-Sulfonate	5.0

Working Example #1

The objective of working example #1 was to determine if 0.5% and 1.0% lactic acid alone and in combination with Test Formula #1 and/or steam achieved a reduction in the bacterial flora present on prerigor beef samples. An exposure time of 10 minutes was utilized for all applications and testing was performed at 33°C.

Operating Procedure:

Sixteen prerigor beef samples were obtained and kept in a cooler until time of testing. Samples were aseptically divided in half. Eight different test treatments were utilized with four replicate pieces per treatment with the exception of the steam + 0.5% lactic acid treatment which only had three replicate pieces. Two cores (4.3 cm diameter) were taken from each replicate piece before and after treatment, combined into 99 mL of Phosphate Buffered Dilution water, stomached for 1 minutes and then serially diluted and plated using pour plate technique.

Test Products:

1. Test Formula #1 at 200 ppm Total Peracid
2. Test Formula #1 at 200 ppm Total Peracid + 0.5% Lactic Acid
3. Test Formula #1 at 200 ppm Total Peracid + 1.0% Lactic Acid
4. 0.5% Lactic Acid
5. Steam Alone, followed by a sterile water rinse

---

1 A mixture of peroxy acetic and peroxyoctanoic acids is used. After application the composition is maintained in situ as a mixture of acid and peracid through the action of the H_2O_2.

6. Steam + Test Formula #1 at 200 ppm Total Peracid, followed by a sterile water rinse
7. Steam + Test Formula #1 at 200 ppm Total Peracid + 0.5% Lactic Acid, followed by a sterile water rinse
8. Steam + 0.5% Lactic Acid followed by a sterile water rinse

Peracid Product Titrated	Actual Titrated
Peracid	
Test Formula #1 at 200 ppm	212 ppm
200 ppm Test Formula #1 + 0.5% Lactic Acid	220 ppm
200 ppm Test Formula #1 + 1.0% Lactic Acid	192 ppm
Test Formula #1 + Steam	210 ppm
Test Formula #1 + 0.5% Lactic Acid + Steam	220 ppm

Product Application: All product use solutions were applied by a spray application for 10 seconds. This delivered approximately 150 mL of product. An exposure time of 10 minutes was utilized, followed by a 10 second sterile water rinse, if applicable.

Neutralizer: 99 mL of Phosphate Buffered Dilution Water

Dilutions Plated: 10^{0}, 10^{-1}, 10^{-2} for Total Plate Count Before
10^{0}, 10^{-1} for Total Plate Count After

Plating Medium: Tryptone Glucose Extract Agar

Incubation: 26°C for 72 hours

Steam Application Parameters

Test Product Application	Observations
Steam Alone	**1st Replicate:** Starting temperature was 86°C, ending at 92°C. A 17 second exposure time was utilized and a 10 second delay occurred prior to the sterile water rinse for 10 seconds. **2nd Replicate:** Starting temperature was high 80°C, ending at 90+°C. **3rd & 4th Replicates:** Starting temperature was 82°C, ending at 87°C. An 8 second exposure time and a 10 second sterile water rinse were utilized for replicates 2, 3 and 4.
Test Formula #1 + Steam	**1st Replicate:** Starting temperature was 82°C, ending at 87°C. **2nd Replicate:** Starting temperature was 80°C, ending at 84°C. **3rd Replicate:** Starting temperature was 83°C, ending at 88°C. **4th Replicate:** Starting temperature was 86°C, ending at 89°C. An 8 second exposure time and a 10 second sterile water rinse were utilized for all replicates.
Test Formula #1 + 0.5% Lactic Acid + Steam	**1st Replicate:** Starting temperature was 88°C, ending at 91.5°C. **2nd Replicate:** Starting temperature was 86.7°C, ending at 90+?°C. **3rd and 4th Replicates:** Temperatures were not recorded. An 8 second exposure time and a 10 second sterile water rinse utilized for all replicates.
0.5% Lactic Acid + Steam	**1st Replicate:** Starting temperature was 84°C, ending at 88°C. **2nd Replicate:** Starting temperature was not recorded, however the ending temperature was 91°C. **3rd Replicate:** Temperatures were not recorded. An 8 second exposure time and a 10 second sterile water rinse were utilized for all replicates.

Total Plate Count Results

Product Application	Average CFU/100 mL Before	Avg. CFU/ 100 mL After	Avg. Log_{10} Reduc.
Test Formula #1 at 200 ppm	3.3×10^4	7.7×10^3	.80
Test Formula #1 at 200 ppm +0.5% Lactic Acid	2.0×10^5	1.7×10^4	1.08
Test Formula #1 at 200 ppm +1.0% Lactic Acid	4.4×10^4	1.2×10^3	1.31
0.5% Lactic Acid	2.7×10^4	5.4×10^3	0.91
Steam Alone with Sterile Water Rinse	1.2×10^4	2.4×10^3	1.10
Steam + Test Formula #1 at 200 ppm with Sterile Water Rinse	1.5×10^4	8.4×10^2	1.51
Steam + Test Formula #1 at 200 ppm + 0.5 % Lactic Acid With Sterile Water Rinse	3.1×10^5	2.6×10^3	2.55
Steam +0.5% Lactic Acid with Sterile Water Rinse	2.5×10^4	9.3×10^2	1.69

CONCLUSIONS:

The application of Steam with Test Formula #1 at 200 ppm in combination with 0.5% Lactic Acid outperformed all other treatments by achieving an average of a 2.55 $\log_{10}$ reduction on the surface of prerigor meat. Steam alone, provided an average 1.10 $\log_{10}$ reduction with temperatures ranging from 80-92°C. Test Formula #1 at 200 ppm in combination with 0.5% Lactic Acid only provided an average 1.10 $\log_{10}$ reduction in comparison to an average 1.31 $\log_{10}$ reduction in combination with 1.0% Lactic Acid.

The purpose of the remaining working examples was to determine if the use of higher spray pressures, particularly those above 100 psi, would increase the antimicrobial efficacy of the compositions of the invention.

Working Example #2

The objective of the testing was to determine the efficacy of various antimicrobial treatments with extended spray and exposure times against the bacterial flora of prerigor beef.

Test Method/Parameters:

Prerigor beef samples were obtained and kept in a cooler at ambient temperature until time of testing. Ten different test treatments were utilized with four replicates per treatment. Two cores (4.3 cm diameter) were taken as each replicate from one piece for both before- and after- treatment samples and combined into 99 mL of Letheen Broth. The cores/neutralizer mixtures were stomached for 1 minute and then serially diluted and plated using pour plate technique.

Test Products: **Test Formula #1*** at 200 ppm Peracid = 0.42% (4.2 mL were added to 995 .8 mL tap water)

to **Test Formula #1*** at 500 ppm Peracid (10.5 mL were added 989.5 mL tap water)

0.5% Lactic Acid

total * **Test Formula #1**, batch # Si120972, was titrated at 4.76% peracid.

Application: and test

Eight cores (2 cores per replicate) were placed onto a clean sanitary screen. The cores were sprayed with the appropriate product utilizing a 10- or 30- second spray application time. For each replicate, two cores were removed after a 10-minute exposure time and placed into a stomacher bag containing 99 mL of neutralizer.

Neutralizer: 99 mL Letheen Broth

Dilutions: 10^{0}, 10^{-1}, 10^{-2} for Total Plate Count Before
10^{0}, 10^{-1} for Total Plate Count After

Plating Medium: Tryptone Glucose Extract Agar

Incubation: 26°C for 72 hours

Calculations: Average CFU/plate = (All eight counts from four replicates / 4)

Average CFU/plate x 100 = Average CFU/100 mL = Y

$$\text{Average}\frac{\text{CFU}}{\text{cm}^2} = \frac{\text{Y}}{2\pi r^2}$$

Dilution = 10, 100, or 1000

r = 2.15 cm
2 = # of cores

Product Application	Average CFU/100 mL Before	Avg. CFU/ 100 mL After	Avg. Log_{10} Reduc.
Water Control 98°F 25 psi pressure, 10 sec. spray	3.6×10^4	4.7×10^4	0.05
Water Control 120° 50 psi pressure, 30 sec. spray	1.2×10^5	1.9×10^5	-0.21
0.5% Lactic Acid 98°F 25 psi pressure, 10 sec spray	1.6×10^4	1.5×10^4	-0.01
0.5% Lactic Acid 120°F 25 psi pressure, 10 sec. spray	1.0×10^5	8.4×10^4	0.07
Test Formula #1 at 200 ppm Peracid 90°F 50 psi pressure, 10 sec spray	2.3×10^4	8.7×10^3	0.41
Test Formula #1 at 200 ppm Peracid 120°F 50 psi pressure, 10 sec spray	1.5×10^5	1.6×10^4	0.97
Test Formula #1 at 200 ppm Peracid 120°F 50 psi pressure, 30 sec spray	9.0×10^4	3.9×10^4	0.37
Test Formula #1 at 200 ppm Peracid 120° 25 psi pressure, 30 sec spray	6.5×10^5	6.4×10^5 1.9×10^4*	0.01 1.65*
Test Formula #1 at 500 ppm Peracid 98°F 25 psi pressure, 30 sec. spray	4.5×10^4	5.3×10^3	0.93
Test Formula #1 at 500 ppm Peracid 120°F 25 psi pressure, 10 sec. spray	4.9×10^4	1.1×10^4	0.67

*Average and Log_{10} Reduction not including replicate #3.

CONCLUSIONS:

Overall, the highest reductions in the bacteria flora on the surface of prerigor beef were seen with the following treatments:

- **Test Formula #1** at 200 ppm total peracid at 50 psi pressure with a 10-second spray time at 120°F achieved an average 0.97 $\log_{10}$ reduction.
- **Test Formula #1** at 500 ppm total peracid at 25 psi pressure with a 30-second spray at 98°F achieved an average 0.93 $\log_{10}$ reduction.

In regard to temperature, 120°F resulted in higher efficacy with **Test Formula #1** at 200 ppm total peracid at 50 psi pressure with a 10-second spray time, with a 0.97 $\log_{10}$ reduction versus a 0.41 $\log_{10}$ reduction at 98°F.

Working Example #3

The objective of the testing was to determine the efficacy of **Test Formula #1** at 200 ppm total peracid with a high pressure application spray at 100°F against the bacterial flora of prerigor beef.

Test Method/Parameters:

Prerigor beef samples were obtained and kept in a cooler at ambient temperature until time of testing. Four different test treatments were utilized with four replicates per treatment. Two cores (4.3 cm diameter) were taken as each replicate from one piece for both before and after treatment samples and combined into 99 mL of Letheen Broth. The cores/neutralizer mixtures were stomached for 1 minute and then serially diluted and plated using pour plate technique.

Test Product: **Test Formula #1** at 200 ppm total peracid

(Batch # Si120972, was titrated at 4.76% total peracid)

Application: Eight cores (2 cores per replicate) were aseptically removed from each sample before treatment. These were used for the before treatment samples. The remaining sample was placed onto a clean and sanitary screen. The sample was then sprayed with Vortex at approximately 200 ppm total peracid utilizing a 5-, 10- or 30- second spray application time. For each replicate, two cores were removed after a 10-minute exposure time and placed into a stomacher bag containing 99 mL of neutralizer.

Neutralizer: 99 mL Letheen Broth

Dilutions: 10^0, 10^{-1}, 10^{-2} for Total Plate Count Before
10^0, 10^{-1} for Total Plate Count After

Plating Medium: Tryptone Glucose Extract Agar

Incubation: 26°C for 72 hours

Calculations: Average CFU/plate = (All eight counts from four replicates / 4)

Average CFU/plate x 100 = Average CFU/100 mL = Y

$$\text{Average}\frac{\text{CFU}}{\text{cm}^2} = \frac{Y}{2\pi r^2}$$

Dilution = 10, 100, or 1000

r = 2.15 cm
2 = # of cores

Product Application	Average CFU/100 mL Before	Avg. CFU/ 100 mL After	Avg. Log_{10} Reduc.
Water Control ~230 psi pressure, 30 sec. spray	5.6×10^5	2.7×10^4	1.31
Test Formula #1 at 200 ppm Peracid ~230 psi pressure, 10 sec spray	~1.9×10^6	~2.1×10^5	~0.96
Test Formula #1 at 200 ppm Peracid ~230 psi pressure, 5 sec spray	~2.8×10^6	2.0×10^5	1.15
Test Formula #1 at 200 ppm Peracid ~230 psi pressure, 30 sec spray	2.1×10^6	<100	>2.90

CONCLUSIONS:

Test Formula #1 at 200 ppm peracid with a 30-second exposure time utilizing a high-pressure spray of 230 psi at the nozzle with a distance of approximately 75 cm achieved the highest reduction with <3.4 CFU/cm^2 surviving after a 10-minute exposure time at ~110°F. Utilizing this procedure, a >2.90 log reduction was achieved.

Working Example #4

The objective of the testing was to determine the efficacy of **Test Formula #1** at approximately 50, 100 and 200 ppm total peracid with a high pressure application spray at elevated temperatures in comparison to **Lactic Acid** against the bacterial flora of prerigor beef.

Test Method Parameters:

Prerigor beef samples were obtained and kept in a cooler at ambient temperature until time of testing. Four different test treatments were utilized with four replicates per treatment. Two cores (4.3 cm diameter) were taken as each replicate from one piece for both before- and after-treatment samples and combined into 99 mL of Letheen Broth. The cores/neutralizer mixtures were stomached for 1 minute and then serially diluted and plated using pour plate technique.

Test Product:	**Test Formula #1** at 50, 100 and 200 ppm total peracid **Lactic Acid** (88% concentrate) (Batch # Sil20972, was titrated at 4.76% total peracid)
Application:	Eight cores (2 cores per replicate) were aseptically removed from each sample before treatment. These were used for the before-treatment samples. The remaining sample was placed onto a clean and sanitary screen. The sample was then sprayed with **Test Formula #1** at approximately 50, 100 or 200 ppm total peracid utilizing a 20- or 30-second spray application time. 0.5% Lactic Acid utilized only the 30-second spray application time. For each replicate, two cores were removed after a 10-minute exposure time and placed into a stomacher bag containing 99 mL of neutralizer.
Neutralizer:	99 mL Letheen Broth
Dilutions:	10^0, 10^{-1}, 10^{-2} for Total Plate Count before 10^0, 10^{-1} for Total Plate Count After
Plating Medium:	Tryptone Glucose Extract Agar
Incubation:	16°C for 72 hours
Calculations:	Average CFU/plate = (All eight counts from four replicates / 4)
	Average CFU/plate x 100 = Average CFU/100 mL = Y
	$\text{Average}\frac{CFU}{cm^2} = \frac{Y}{2\pi r^2}$
	Dilution = 10, 100 or 10000
	r = 2.15 cm 2 = # of cores

Product Application	Average CFU/100 mL Before	Avg. CFU/ 100 mL After	Avg. Log_{10} Reduc.
Test Formula #1 at 200 ppm Peracid ~230 psi pressure, 30 sec. spray	3.7×10^4	<100	>2.58
Test Formula #1 at 200 ppm Peracid ~230 psi pressure 20 sec. spray	3.1×10^5	3.3×10^3	2.00
Test Formula #1 at 100 ppm Peracid ~230 psi pressure, 30 sec. spray	1.3×10^6	7.9×10^3	2.22
Test Formula #1 at 100 ppm Peracid ~230 psi pressure 20 sec. spray	2.0×10^5	4.3×10^2	2.66
Test Formula #1 at 50 ppm Peracid ~230 psi pressure, 30 sec spray	3.1×10^5	6.3×10^3	1.70
Test Formula #1 at 200 ppm Peracid ~65 psi pressure 30 sec. spray	2.1×10^5	8.7×10^4	0.38
~0.5% Lactic Acid ~230 psi pressure, 30 sec. spray	8.7×10^5	2.3×10^4	1.58

CONCLUSIONS:

Test Formula #1 at 200 ppm total peracid sprayed for 30 seconds at ~230 psi pressure achieved the highest reduction of bacteria present on the surface of prerigor meat with a >2.58 log_{10} reduction. **Test Formula #1** at 200 ppm sprayed for 30 seconds at ~65 psi pressure only achieved an average 0.38 log_{10} reduction.

Working Example #5

The objective of the testing was to determine the efficacy of **Test Formula #1** and **Lactic Acid** against *Listeria innocua* ATCC 33090 with a high-pressure application spray at elevated temperatures.

Test Method/Parameters:

Prerigor beef samples were obtained and kept in a cooler at ambient temperature until time of testing. Samples were cut into 13 cm pieces and 2.0 mL of the inoculum (see Test System Preparation below) was spread evenly over the entire surface of the sample. Inoculated samples were then left at room temperature (~23°C) for ≥ 15 minutes. Four replicate samples were taken (two cores per replicate) before treatment. After each spray treatment, a 10-minute exposure time was utilized, and tahen four replicate samples were taken (two cores per replicate) and stomached for 1 minute, serially diluted and plated using pour plate technique.

Treatments:
1. **Test Formula #1** at 200 ppm total peracid with ~ psi pressure spray, 30 second spray time.
2. **Test Formula #1** at 200 ppm total peracid with ~150 psi pressure spray, 30 second spray time.
3. **Test Formula #1** at 200 ppm total peracid with ~100 psi pressure spray, 30 second spray time.
4. **Water Control** with ~220 psi pressure spray, 30-second spray time.
5. ~0.5% - 0.75% **Lactic Acid** with ~220 psi pressure spray, 30-second spray time.
6. **Test Formula #1** at 100 ppm total peracid with ~220 psi pressure spray, 30 second spray time.
7. **Test Formula #1** at 200 ppm total peracid with ~220 psi pressure spray, 15 second spray time.

* Tiration of the Lactic Acid solution used 12 drops of 1N Sodium Hydroxide for the indicator color change. In preliminary titrations of a 0.5% **Lactic Acid** solution, 7 drops of 1N Sodium Hydroxide were needed. Therefore, the sample was estimated to be at a concentration between 0l75% and 1.0% **Lactic Acid**.

Test Temperature: ~120°F

Test System: *Listeria innocua* ATCC 33090

Test System

Preparation: 25 grams of sterilized cow feces was added into 50 grams of sterile phosphate buffered dilution water and stomached for 1 minute. 60.0 grams from this fecal slurry was transferred to a sterile stomacher bag and 6.0 mL of an ~10^8 CFU/mL *Listeria innocua* 24-hour broth culture (grown in BHI broth at 37°C) was added and mixed. This inoculum was therefore estimated at 10^7 CFU/mL, which yielded approximately 10^5 CFU/cm^2.

Exposure Time: 10 minutes

Neutralizer: 99 mL Letheen Broth

Dilutions: 10^{-4}, 10^{-5}, 10^{16} (for Before Treatment, Inoculation Numbers samples)
10^0, 10^{-1}, 10^{-2} (After Treatment samples)

Plating Medium: *Listeria* Selective Agar

Incubation: 26° for 72 hours

Calculations: Average CFU/plate = (All eight counts from four replicates / 4)

Average CFU/plate x 100 = Average CFU/100 mL = Y

$$\text{Average}\frac{\text{CFU}}{\text{cm}^2} = \frac{\text{Y}}{2\pi r^2}$$

r = 2.15 cm 2 = # of cores

Product Application	Avg. CFU/ 100 mL After	Avg. Log_{10} Reduc.
Test Formula #1 at 200 ppm Peracid ~220 psi pressure 30 second spray*	1.6×10^5	1.97
Test Formula #1 at 200 ppm Peracid ~150 psi pressure 30 second spray*	5.1×10^4	2.45
Test Formula #1 at 200 ppm Peracid ~100 psi pressure 30 second spray*	1.4×10^5	2.03
Water Control ~220 psi pressure 30 second spray	4.9×10^5	1.48
Lactic Acid ~220 psi pressure 30 second spray	3.5×10^5	1.63
Test Formula #1 at 100 ppm Peracid ~220 psi pressure 30 second spray*	1.6×10^5	1.97
Test Formula #1 at 200 ppm Peracid ~100 psi pressure 15 second spray*	2.2×10^5	1.83

CONCLUSIONS:

Treatment at 200 ppm peracid with an ~150 psi spray for 30 seconds achieved an average 2.45 log_{10} reduction of *Listeria innocua* ATCC 33090. Lactic Acid achieved a 1.63 log_{10} reduction of this organism which was only slightly higher than the water control which achieved an average 1.48 log_{10} reduction.

The above discussion, examples, and data illustrate our current understanding of the invention. However, since many variations of the invention can be made without departing form the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

For the purposes of this specification it will be clearly understood that the word "comprising" means "including but not limited to", and that the word "comprises" has a corresponding meaning.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of treating a meat product to reduce a microbial population in the meat product, the method including the steps of:

(a) treating said meat product with an antimicrobial composition including:

(i) an effective antimicrobial amount including at least 2 ppm of one or more mono- or di-peroxycarboxylic acids having up to 12 carbon atoms; and

(ii) an effective antimicrobial amount including at least 20 ppm of one or more carboxylic acids having up to18 carbon atoms; and

(b) reducing the microbial population.

2. The method of claim 1, wherein the population reduction includes at least one $\log_{10}$ reduction in the microbial population.

3. The method of claim 1, wherein the population reduction includes at least two $\log_{10}$ reduction in the microbial population.

4. The method of claim 1, wherein the population reduction includes at least three $\log_{10}$ reduction in the microbial population.

5. The method of claim 1, 2, 3 or 4, wherein the population includes a human pathogen.

6. The method of claim 1, 2, 3 or 4, wherein the population includes *Escherichia coli*.

7. The method of any one of the preceding claims, wherein the meat product is selected from a muscle meat including beef, pork, veal, buffalo or lamb.

8. The method of any one of claims 1 to 6, wherein the meat product is sea food including scallops, shrimp, crab, octopus, mussels, squid or lobster.

9. The method of any one of claims 1 to 6, wherein

AUSTRALIAN PATENT OFFICE

the meat product is poultry including chicken, turkey, ostrich, game hen, squab or pheasant.

10. The method of any one of the preceding claims, wherein the peroxycarboxylic acid includes one or more peroxycarboxylic acids having from 2 to 4 carbon atoms and a peroxycarboxylic acid having from 8 to 12 carbon atoms.

11. The method of any one of claims 1 to 9, wherein the peroxycarboxylic acid includes peroxyacetic acid and peroxoyoctanoic or peroxydecanoic acid, or mixtures thereof.

12. The method of claim 10, wherein the peroxycarboxylic acid having from 2 to 4 carbon atoms is peroxyacetic acid and the peroxycarboxylic acid having from 8 to 12 carbon atoms is peroxyoctanoic acid resulting in a ratio of about 10 to about 1 parts by weight of peroxyacetic acid per each 1 part of carboxylic acid.

13. The method of any one of the preceding claims, wherein the carboxylic acid is acetic acid.

14. The method of any one of claims 1 to 12, wherein the carboxylic acid is an alpha-hydroxy mono or dicarboxylic acid having from 3 to 6 carbon atoms.

15. The method of claim 14, wherein the carboxylic acid is lactic acid.

16. The method of any one of the preceding claims, wherein said antimicrobial composition includes about 2 to 25 parts by weight of hydrogen peroxide per each one million parts of the composition.

17. The method of any one of the preceding claims, wherein said antimicrobial composition is applied to the meat product by means of a spray.

18. The method of any one of claims 1 to 16, wherein said antimicrobial composition is applied to the meat product by means of a fog.

19. The method of any one of claims 1 to 16, wherein said antimicrobial composition is applied to the meat product by means of a foam.

20. The method of any one of claims 1 to 16, wherein

AUSTRALIAN PATENT OFFICE

said antimicrobial composition is applied to the meat product by applying in the form of a thickened or gelled solution.

21. The method of any one of claims 1 to 16, wherein all or part of the meat product is dipped in said antimicrobial composition.

22. The method of claim 21, wherein a solution including the antimicrobial composition is agitated.

23. The method of any one of the preceding claims, which further includes a vacuum treatment step.

24. The method of any one of the preceding claims, which further includes the step of applying an activated light source to said meat product.

25. An antimicrobial composition adapted for cleaning and sanitising meat product including:

(a) 0.5 wt-% to 20 wt-% of a mixture of one or more peroxycarboxylic acids having from 2 to 4 carbon atoms and one or more peroxycarboxylic acids having from 8 to 12 carbon atoms;

(b) from 0.5 wt-% to 60 wt-% of an alpha-hydroxy mono or dicarboxylic acid having from 3 to 6 carbon atoms;

(c) an effective amount of a sequestrant; and

(d) an effective amount of a hydrotope.

26. The composition of claim 25, wherein the peroxycarboxylic acid is a mixture of peroxyacetic acid and peroxyoctanoic or peroxydecanoic acid.

27. The composition of claim 26, wherein the peroxycarboxylic acid is a mixture of peroxyacetic acid and peroxyoctanoic acid in a ratio of 10:1 to 1:1.

28. The composition of any one of claims 25 to 27, wherein the alpha-hydroxy mono or dicarboxylic acid is lactic acid.

29. The composition of any one of claims 25 to 28, which further includes 1 wt-% to 35 wt-% of hydrogen peroxide.

AUSTRALIAN PATENT OFFICE

30. The composition of any one of claims 25 to 29, which further includes from 0.01 wt-% to 10 wt-% of a sequestering agent.

31. The composition of claim 30, wherein the sequestering agent is 1-hydroxyethylidene-1,1-diphosphonic acid.

32. The composition of any one of claims 25 to 31, which further includes from 0.1 to 20 wt-% of a hydrotope.

33. The composition of any one of claims 25 to 32, which further includes from 0.01 to 10 wt-% of a thickening or gelling agent.

34. The composition of any one of claims 25 to 33, which further includes from 1 to 60 wt-% of an organic solvent.

35. An antimicrobial composition adapted for treating meat product consisting essentially of:

(a) a mixture of peroxyacetic and peroxyoctanoic acid in a ratio of 10:1 to 1:1;

(b) from 0.1 wt-% to 10 wt-% of lactic acid;

(c) from 4 wt-% to 10 wt% of hydrogen peroxide; and

(d) from 0.5 wt-% to 1.5 wt-% of a sequestering agent.

36. The composition of claim 35, wherein the sequestering agent is 1-hydroxyethylidene-1,1-diphosphonic acid.

37. A method of treating a meat product to reduce a microbial population in the meat product, the method including the steps of:

(a) spraying an aqueous antimicrobial treatment composition onto said meat product at a pressure of at least 50 psi at a temperature of up to about 60°C resulting in a contact time of at least 30 seconds, the antimicrobial composition including an effective antimicrobial amount including at

AUSTRALIAN PATENT OFFICE

least 2 ppm of one or more carboxylic acid, peroxycarboxylic acid or mixtures thereof; and

(b) achieving at least one $\log_{10}$ reduction in the microbial population.

38. The method of claim 37, wherein the antimicrobial composition comprises an effective antimicrobial amount including at least 2 ppm of one or more peroxycarboxylic acids having up to 12 carbon atoms; and at least 20 parts of one or more carboxylic acids having up to 18 carbon atoms.

39. The method of claim 37, wherein the peroxycarboxylic acid includes peroxyacetic acid, peroxyoctanoic acid, peroxydecanoic acid or mixtures thereof.

40. The method of any one of claims 37 to 39, wherein the carboxylic acid comprises acetic acid, lactic acid or mixtures thereof.

41. The method of any one of claims 37 to 40, wherein the antimicrobial composition comprises at least about 5 wt-% hydrogen peroxide.

42. The method of any one of claims 37 to 41, wherein the antimicrobial compositions are applied by means of an electrostatically accelerated spray.

43. A method of treating a meat product to reduce microbial population in the meat product, the method including the steps of:

(a) placing the meat product in a chamber at atmospheric pressure;

(b) filling the chamber with condensing steam comprising an antimicrobial composition for a short duration; and

(c) quickly venting and cooling the chamber to prevent browning of the meat product;

wherein the duration of the steam thermal process may be from about 5 seconds to about 30 seconds and the chamber

AUSTRALIAN PATENT OFFICE

temperature may reach from 50°C to 93°C.

44. The method of claim 43, wherein the antimicrobial composition includes an effective antimicrobial amount comprising at least 2 ppm of one or more peroxycarboxylic acids having up to 12 carbon atoms; and at least 20 parts of one or more carboxylic acids having up to 18 carbon atoms.

45. The method of claim 44, wherein the peroxycarboxylic acid includes peroxyacetic acid, peroxyoctanoic acid, peroxydecanoic acid or mixtures thereof.

46. The method of claim 44 or 45, wherein the carboxylic acid includes acetic acid, lactic acid or mixtures thereof.

47. The method of any one of claims 44 to 46, wherein the antimicrobial composition includes at least 5 wt-% hydrogen peroxide.

48. The method of any one of claims 44 to 47, wherein the antimicrobial compositions are applied by means of an electrostatically accelerated spray.

49. A method of treating a meat product to reduce a microbial population in the meat product substantially as hereinbefore described with reference to any one of the foregoing examples.

50. An antimicrobial composition adapted for cleaning and sanitising meat product substantially as hereinbefore described with reference to any one of the foregoing examples

Dated this 21st day of November 2002

ECOLAB INC.

By their Patent Attorneys

GRIFFITH HACK

Fellows Institute of Patent and

Trade Mark Attorneys of Australia

AUSTRALIAN PATENT OFFICE