

METHOD OF PROTECTING AN ANIMAL SKIN PRODUCT FROM METALLOPROTEINASE ACTIVITY

FIELD OF INVENTION

[0001] The present invention relates to leather processing and in particular, to a method of protecting animal skins or hides from enzymatic degradation by treating the animal skins or hides with a metalloproteinase inhibitor.

BACKGROUND OF THE INVENTION

[0002] Deterioration of fresh hides and skins due to microbial growth and activity is a major problem in the leather and tanning industry and a major cause of economic loss. Harmful microorganisms such as bacteria and fungi may come from many sources, including the animal skin itself, the slaughterhouse and the leather tanning and processing environment. Fresh skins and hides have a high moisture content, a favourable pH, and large amounts of available nutrients, permitting the rapid growth of microorganisms, which results in the deterioration of essential components of the skins and hides.

[0003] Microorganisms that grow on or near hides and skins can cause putrefaction of the hides and skins by producing enzymes such as collagenase that can degrade the protein component of the hides or skins. Proteins constitute about 33% of the composition of fresh hides or skins (the remainder being primarily water and fat), and much of this protein is collagen. (John Henry Sharphouse, *Leather Technicians Handbook*. 1995. Leather Producers' Association. Moulton Park, Northhampton, Great Britain.) Finished leather is primarily collagen, which is crosslinked during the tanning process. Since finished leather is primarily collagen, damage to

skins and hides from collagenase produced by microorganisms during stages of processing and storing animal skins and hides is particularly harmful and adversely affects the quality of the finished leather.

[0004] Several methods have been used to temporarily preserve skins and hides while they are in storage prior to processing or while they are being transported to other locations for processing. In particular, biocides or preservatives have been used in an effort to control harmful microorganisms. (See, for example, the following U.S. patents incorporated herein by reference: U.S. Patent No. 4,164,393, U.S. Patent No. 4,224,028, U.S. Patent No. 4,278,432, U.S. Patent No. 4,322,210, U.S. Patent No. 4,379,706, U.S. Patent No. 4,478,728, U.S. Patent No. 4,889,811, U.S. Patent No. 4,935,031, U.S. Patent No. 4,985,039, U.S. Patent No. 5,096,553, U.S. Patent No. 5,435,808, U.S. Patent No. 6,086,633, and U.S. Patent No. 6,451,062.) While biocides or preservatives may work well in inhibiting or killing microorganisms, they are generally not effective to block collagenase or other enzymes responsible for degrading collagen. These enzymes can remain active and can cause damage even after the microorganisms that produced them have been killed. Additionally, the use of biocides to preserve skins and hides can be expensive or impractical, since large amounts of biocides are required to kill enough microorganisms to completely prevent collagenase production. Further, a biocide is not effective against endogenous enzymes, that is, against enzymes that were produced by the animal itself and that remain in the skin or hide after slaughter. Moreover, in some instances, it may not be desirable to completely wipe out all of the microorganisms that come into contact with a skin or hide, since some microorganisms may produce enzymes that are useful in breaking down extraneous organic material attached to the hide or skin.

[0005] Collagenase belongs to the class of proteins known as metalloproteinases, which are

proteases that require the presence of a metal ion in order to function. It has been previously reported that the activity of metalloproteinases can be blocked or inhibited by exposing the metalloproteinases to a metal chelator. For example, aminocarboxylic acid derivatives such as ethylenediaminetetraacetic acid (EDTA) and ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid (EGTA) are metal chelators that are known to inhibit metalloproteinases such as collagenase. (David S. Auld 1995 "Removal and replacement of metal ions in metalloproteinases." In: Allan J. Barrett (Ed), *Methods of Enzymology*, 248:228-242. Academic Press. New York). However, to date, the use of metal chelators to inhibit metalloproteinases has been primarily in the fields of medicine and biotechnology. The usefulness and effectiveness of aminocarboxylic acid derivatives as collagenase inhibitors has not been known or appreciated in the leather and tanning industry and the use of protease inhibitors to protect skins and hides has not been previously reported.

[0006] Accordingly, there is a need for a composition and method to protect skins and hides from proteolytic enzymes such as metalloproteinases that come into contact with the skins and hides or that are present in fluids or surfaces with which the skins and hides come into contact, particularly during stages of a leather tanning process.

[0007] Further, there is a need for a composition and method to protect skins and hides from metalloproteinases that are produced by microorganisms or that are endogenous enzymes that were present in the animal skin or hide at the time that the animal was slaughtered.

[0008] Further, there is a need for a composition and method to protect skins and hides from metalloproteinases using compounds and compositions that are inexpensive and readily obtainable.

[0009] Further, there is a need for a composition and method to protect skins and hides from

metalloproteinases using compounds and compositions that have a low toxicity, are environmentally friendly and are compatible with tanning and leather processes.

SUMMARY OF THE INVENTION

[0010] A feature of the present invention is to provide a composition and method for protecting animal skins and hides from proteolytic enzymes such as metalloproteinases that are produced by microorganisms that come into contact with the skins and hides or that are present in fluids or surfaces with which the skins and hides come into contact, for example during a leather tanning process, or that are endogenous proteolytic enzymes that were present in the skin or hide when the animal was slaughtered.

[0011] The present invention further provides a composition and method to protect skins and hides from metalloproteinases using compounds and compositions that are inexpensive and readily obtainable.

[0012] The present invention further provides a composition and method to protect skins and hides from metalloproteinases using compounds and compositions that have a low toxicity, are environmentally friendly and/or are compatible with tanning and leather processes.

[0013] Additional advantages of the present invention will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practice of the present invention. The goals and advantages of the present invention will be realized and attained by means of the elements particularly pointed out in the appended claims.

[0014] To achieve the above noted goals and in accordance with the purpose of the present invention, as embodied and broadly described herein, the present invention provides a method of preventing or inhibiting putrefaction, degradation, and/or deterioration of an animal skin or hide

due to an action of a metalloproteinase. The method includes applying a solution containing at least one metalloproteinase inhibitor to the animal skin or hide or to a fluid or solid surface that contacts the animal skin or hide.

[0015] The present invention further provides a method of preventing or inhibiting putrefaction, degradation or deterioration of an animal skin or hide, the method comprising applying a solution containing at least one polyaminocarboxylic acid, or a salt thereof, to the animal skin or hide or to a fluid or solid surface that contacts the animal skin or hide.

[0016] The present invention further provides a method of producing leather including the steps of detaching an animal skin or hide from a slaughtered animal, curing the animal skin or hide, soaking the cured animal skin or hide, removing flesh and hair from the soaked animal skin or hide, and tanning the animal skin or hide from which the flesh and hair has been removed to form leather, wherein after the step of detaching the animal skin or hide from the slaughtered animal and before the step of tanning the animal skin or hide from which the flesh and hair has been removed to form leather, a solution containing at least one metalloproteinase inhibitor is applied to the animal skin or hide or to a fluid or solid surface that contacts the animal skin or hide in a sufficient amount to prevent or inhibit degradation or deterioration of the animal skin or hide due to an action of a metalloproteinase.

[0017] The present invention further provides a composition containing at least an aqueous dipping or soaking solution wherein at least one animal skin or hide can be dipped or soaked therein, wherein the dipping or soaking solution contains at least one metalloproteinase inhibitor.

[0018] The present invention further provides a composition containing an animal skin or hide having a solution containing at least one metalloproteinase inhibitor applied to at least one surface thereof.

[0019] It is to be understood that both the foregoing general description and the following detailed description are exemplary only and are not restrictive of the present invention, as claimed. All patents, patent applications, and publications mentioned above and throughout the present application are incorporated in their entirety by reference herein.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0020] The present invention is directed to a method of treating an animal skin or hide to prevent putrefaction, degradation, or deterioration caused at least in part by proteolytic enzymes, such as metalloproteinases.

[0021] As used herein, the terms “skin,” “animal skin,” “hide,” or “animal hide” are all used interchangeably to refer to the flayed or stripped skin or outer layer of an animal, particularly of an animal whose skin is useful for converting into leather. Examples of animals from which skin can be taken to make leather include, but are not limited to, cattle, pigs, deer, kangaroos, goats, camels, sheep, horses, alligators, crocodiles, snakes, birds, seals, eel, and walrus. The term “skin or hide” is intended to refer to a skin or hide at any stage of processing after it is removed from a carcass, including any intermediate stage in leather processing or preservation.

[0022] The method of the present invention can be carried out at any time after an animal dies or is slaughtered and its skin or hide is flayed or stripped from the animal carcass. In typical leather processing, for example, an animal skin or hide is detached from a fallen or slaughtered animal, and then the animal skin or hide is cleaned, cured, soaked, treated for removal of flesh and hair, bated, and tanned to form leather. The animal skin or hide may be stored or transported to another location after flaying and before the beginning of leather processing. Many variations of these processes are known. The method of the present invention can be carried out at the same

time as any of these processes or can be carried out as a separate step between any of these processes. For example, a skin or hide can be treated with a metalloproteinase inhibitor according to method of the present invention at least once between the time that a skin or hide is stripped from an animal and the time that a tanning process has been carried out. Typically, it is no longer necessary to treat a skin or hide after it has been tanned, since the tanning process typically causes crosslinking of collagen fibers, making them less susceptible to enzymatic attack. Moreover, the method of the present invention is not limited to leather processing and can be combined with any other process for preserving a skin or hide. For example, the method of the present invention can be used if a skin or hide is to be dried without tanning.

[0023] In an embodiment of the method of the present invention, a metalloproteinase inhibitor is applied to an animal skin or hide or to a fluid that contacts the skin or hide or to a surface that comes into contact with the skin or hide in order to prevent or inhibit putrefaction, degradation, or deterioration of the animal skin or hide, particularly putrefaction, degradation, or deterioration due at least in part to the action of a metalloproteinase. As used herein, the term “proteolytic enzyme” refers to any enzyme from a bacteria, fungi, or animal source that cleaves or hydrolyzes peptide bonds and breaks up a protein. The terms “metalloproteinase,” “metalloprotease,” and “metallopeptidase” are used interchangeably to refer to proteolytic enzymes that require a metal ion in order to function. As an example, collagenase is a metalloproteinase that hydrolyzes peptide bonds of collagen and that requires a zinc ion (e.g., Zn^{2+}) at its catalytic site.

[0024] The metalloproteinase inhibitor used in the method of the present invention is a material, such as a compound, or a mixture of compounds, or a composition that is capable of preventing or inhibiting the action of at least one metalloproteinase. As a non-limiting example,

an inhibitor of a metalloproteinase can be a chelator, such as a chelator of a divalent metal ion, that can act to inhibit a metalloproteinase by binding to the metal ion required for the function of the metalloproteinase. For example, a metal chelator can bind to the zinc ion at the catalytic site of a collagenase, thereby blocking, or preventing, or reducing the action of the collagenase. The metalloproteinase inhibitor may be, but is not limited to, an aminocarboxylic acid or a polyaminocarboxylic acid or a salt thereof. As used herein, the term "polyaminocarboxylic acid" refers to an aminocarboxylic compound that contains more than one amine. Preferred chelators are compounds that have at least two groups that can bind to a metal ion, such as, for example, at least two carboxylic acid groups. Another way of stating this is that the chelator is preferably at least bidentate. Non-limiting examples of metalloproteinase inhibitors include ethylenediaminetetraacetic acid (EDTA) or a salt thereof, such as, for example, ethylenediaminetetraacetic acid disodium salt (Na_2EDTA or disodium EDTA), ethylenediaminetetraacetic acid trisodium salt (Na_3EDTA or trisodium EDTA), ethylenediaminetetraacetic acid tetrasodium salt (Na_4EDTA or tetrasodium EDTA), ethylenediaminetetraacetic acid dipotassium salt (K_2EDTA), ethylenediaminetetraacetic acid tripotassium salt (K_3EDTA), ethylenediaminetetraacetic acid ammonium salt (NH_4EDTA), or ethylenediaminetetraacetic acid diammonium salt ($(\text{NH}_4)_2\text{EDTA}$). Other non-limiting examples include ethylenediaminetriacetic acid (ED_3A) or a salt thereof. Other non-limiting examples of metalloproteinase inhibitors include ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid (EGTA) or a salt thereof, such as, for example, the tetrasodium salt, Na_4EGTA . Examples of aminocarboxylic acids, polyaminocarboxylic acids and salts thereof, and methods of their preparation are disclosed, for example, in the following U.S. patents incorporated herein by reference: U.S. Patent No. 2,407,645, U.S. Patent No. 5,250,728, U.S. Patent No. 5,449,822, and

U.S. Patent No. 6,297,397. EDTA and EGTA are commercially available, and their salts are either commercially available or readily prepared by known methods using commercially available raw materials. These compounds are typically inexpensive and have an acceptable toxicity and an acceptable environmental cost. Other non-limiting examples of metalloproteinase inhibitors include S,S'-ethylenediamine disuccinic acid (EDDS), 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid (CDTA) and N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid (HEEDTA). Still other non-limiting examples of metalloproteinase inhibitors include methylglycinediacetic acid (MGDA), N,N-bis(carboxymethyl)glutamate (GLUDA), ortho-phenanthroline, 8-hydroxyquinoline, and phosphonic acid derivatives such as amino-tris methylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 2", diethylene triamine pentamethylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Busperse 254", 2-phosphono-1,2,4-butanetricarboxylic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 9", hydroxyethylidene-diphosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 6", or a blend of 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), e.g., sold by Buckman Laboratories under the tradename "BPS 319." Still other examples of metalloproteinase inhibitors include citric acid and salts of citric acid, gluconic acid and salts of gluconic acid, cysteine, iodoacetic acid and sodium iodoacetate. Mixtures, in any combination, of any of the compounds named herein may also be used.

[0025] For purposes of the present invention, more than one metalloproteinase inhibitor can be used at one time, different times, or sequentially, or in any combination.

[0026] As used herein, the phrase "preventing or inhibiting putrefaction, degradation, or deterioration of an animal skin or hide due to an action of a metalloproteinase" refers to any

reduction in the putrefaction, degradation, or deterioration of an animal skin or hide and is not meant to impose a requirement that all metalloproteinase activity and all putrefaction, degradation or deterioration of an animal skin or hide due to an action of a metalloproteinases be completely stopped, though preferably, all or substantially all metalloproteinase activity is stopped. For instance, preferably, at least 90%, at least 95%, at least 99% of all metalloproteinase activity and/or related effects is stopped.

[0027] The metalloproteinase inhibitor may be applied to an animal skin or hide by any convenient method, such as, for example, by applying the metalloproteinase inhibitor directly to the animal skin or hide or by combining the metalloproteinase inhibitor with a liquid such as, for example, water, to form a solution and spraying the solution onto the animal skin or hide. If the metalloproteinase inhibitor is applied directly to the animal skin or hide, instead of in a solution, it is not admixed with an extender or carrier material. The metalloproteinase inhibitor can be applied by drumming, dipping, spraying, spreading, rolling, and/or coating techniques. Essentially, any technique that can apply a substance to a substrate can be used in the present invention. The metalloproteinase inhibitor can be combined in a solution with other components as long as the other components do not adversely affect the effectiveness or stability of the metalloproteinase inhibitor. In one or more embodiments, it is not necessary or recommended to combine the metalloproteinase with an extender or carrier (e.g., solid), such as a solid absorbent material, like sawdust. In one or more embodiments, the metalloproteinase inhibitor can be applied alone as a solid, e.g., powder, or liquid without any solid extender or carrier, like sawdust. In liquid form, such as solutions, a solid extender or carrier is preferably not used, since such an extender or carrier is not soluble in the solution and/or is not dispersible, and/or floats, and/or interferes with the leather processing system.

[0028] Further, the metalloproteinase inhibitor can be combined with any liquid bath or process water used in treating animal skins or hides as long as it does not interfere with such treatment. As a non-limiting example, an aqueous solution containing the metalloproteinase inhibitor may be sprayed onto an animal skin or hide immediately after flaying (for example, within hours of flaying) to provide immediate protection against putrefaction. The aqueous solution may also contain bactericides, fungicides, and/or insecticides and/or may contain agents for washing or cleaning the animal skin or hide. As another non-limiting example, for short term preservation of an animal skin or hide in preparation for storage or transportation, the animal skin or hide may be dipped or soaked in a chilling solution containing the metalloproteinase inhibitor. Adding a metalloproteinase inhibitor to a chilling solution may allow for chilling to be done at a much higher temperature than usual, thereby reducing energy costs. The reason that chilling can be carried out at a higher temperature is that if metalloproteinase activity is inhibited by the metalloproteinase inhibitor, it becomes less crucial to completely retard bacterial growth by chilling to very low temperatures. As an example, the chilling solution may be at a temperature of greater than freezing and lower than room temperature (e.g., less than 30°C). As another non-limiting example, the metalloproteinase inhibitor can be combined with an aqueous brining solution, such as a saturated or supersaturated solution of sodium chloride in water, into which animal hides are dipped or soaked, or can be combined with a curing or pickling solution. As another non-limiting example, the metalloproteinase solution may be added to any aqueous solution used for dehairing, dewooling, liming, fleshing or deliming. As another non-limiting example, the metalloproteinase inhibitor can be added to any dipping or soaking solution that is used to soak, soften or hydrate an animal skin or hide.

[0029] The amount of the metalloproteinase inhibitor applied to the animal skin or hide is not

critical and can be any amount effective to prevent or inhibit the putrefaction, degradation, and/or deterioration of an animal skin or hide due to an action of a metalloproteinase. The amount of metalloproteinase inhibitor can vary, for example, according to the method of application of the metalloproteinase inhibitor, according to environmental conditions, according to the amount and condition of the metalloproteinase thought to be present, and/or according to the degree of prevention or inhibition desired. For example, the amount of the metalloproteinase inhibitor added to an animal skin or hide can be from about 0.00001% to about 10% or more by weight based on the animal skin or hide. As another example, the amount of the metalloproteinase inhibitor added to an animal skin or hide can be from about 0.0001% to about 5% by weight based on the animal skin or hide. As another example, the amount of the metalloproteinase inhibitor added to an animal skin or hide can be from about 0.001% to about 2% by weight based on the animal skin or hide. When the metalloproteinase inhibitor is combined with a fluid, the fluid should be agitated to spread the metalloproteinase inhibitor throughout the fluid, and when animal skins or hides are added to a fluid such as a dipping or soaking solution or bath, the animal skins or hides are preferably drummed to spread the metalloproteinase throughout the animal skins or hides.

[0030] The metalloproteinase inhibitor may also be added to a fluid that comes into contact with an animal skin or hide such as, for example, any dipping or soaking solution or bath in which animal skins, pelts, or hides are dipped or soaked during leather processing or preservation. Adding the metalloproteinase inhibitor to a fluid not only provides a way of delivering an effective amount of a metalloproteinase inhibitor to an animal skin or hide, as discussed above, but also reduces the likelihood that a metalloproteinase can be spread from one animal skin or hide to another or from one batch of animal skins or hides to another, such as

could happen when more than one animal skin or hide share a dipping or soaking solution or bath or when a dipping or soaking solution or bath is reused to treat more than one batch of animal skins or hides. As a non-limiting example, if an aqueous dipping, soaking, brining, curing, or pickling solution for treating animal skins or hides is reused, a metalloproteinase inhibitor may be added to the aqueous dipping, soaking, brining, curing, or pickling solution between the times that it is used, to deactivate any metalloproteinase that may remain in the solution. The amount of the metalloproteinase inhibitor added to a fluid is not critical and can be a concentration that is substantially less than the concentration at which the metalloproteinase inhibitor becomes lethal to microorganisms. For example, the amount of the metalloproteinase inhibitor added to the fluid can be from about 0.00001% to about 10% or more, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight of the fluid. Alternatively, the amount of the metalloproteinase inhibitor added to the fluid can be from about 0.00001% to about 10% or more, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight of the animal skins or hides that will be dipped or soaked in the fluid.

[0031] The metalloproteinase inhibitor may also be applied to any solid surface that comes into direct or indirect contact with an animal skin or hide to inactivate or inhibit metalloproteinases that may be produced, for example, by bacterial or fungal contaminants on the solid surface and to reduce the likelihood that a metalloproteinase can be spread from the solid surface to the animal skin or hide or from one animal skin or hide to another. As used herein, the term "solid surface" refers to any surface in a slaughterhouse or leather processing area or tanning facility, such as walls, raceways, floors, platforms, frames, hoists, pallets, tables, hooks, or cutting instruments in a slaughterhouse, leather processing facility, or hide storage facility that

the animal skin or hide may come into contact with during slaughter, storage or processing. The term "solid surface" is not meant to include particulate materials. It is intended that the method of the present invention also include the treatment of solid surfaces that indirectly contact an animal skin or hide. For example, a surface in a leather processing facility may harbor microorganisms that produce metalloproteinases, and such metalloproteinases may be splashed onto an animal skin or hide or may be splashed onto a surface that directly contacts an animal skin or hide. It can readily be seen that it would be desirable to treat such surfaces with a metalloproteinase inhibitor as well as those surfaces that directly contact an animal skin or hide. As an example of the method of treating a solid surface, the metalloproteinase inhibitor can be applied directly to a surface that directly or indirectly contacts the animal skin or hide or can be combined with a fluid medium, such as, for example, water, to form a mixture that is applied to the surface. The amount of the metalloproteinase inhibitor added to the liquid that is applied to a surface is not critical. For example, the amount of the metalloproteinase inhibitor added to the liquid can be from about 0.00001% to about 10%, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight of the liquid.

[0032] One of ordinary skill can readily determine the effective amount of the metalloproteinase inhibitor useful for a particular application by simply testing various concentrations prior to treatment of an entire affected substrate or system.

[0033] The present invention further relates to a composition containing a dipping or soaking solution useful for at least one animal skin or hide to be dipped or soaked therein, wherein the dipping or soaking solution contains at least one metalloproteinase inhibitor. The metalloproteinase inhibitor is as defined above and can be a chelator, such as a chelator of a divalent metal ion. As a non-limiting example, the metalloproteinase inhibitor may be an

aminocarboxylic acid or a polyaminocarboxylic acid or a salt thereof. As a non-limiting example, the metalloproteinase inhibitor may be ethylenediaminetetraacetic acid (EDTA) or a salt thereof, such as, for example, ethylenediaminetetraacetic acid disodium salt (Na_2EDTA or disodium EDTA), ethylenediaminetetraacetic acid trisodium salt (Na_3EDTA or trisodium EDTA), ethylenediaminetetraacetic acid tetrasodium salt (Na_4EDTA or tetrasodium EDTA), ethylenediaminetetraacetic acid dipotassium salt (K_2EDTA), ethylenediaminetetraacetic acid tripotassium salt (K_3EDTA), ethylenediaminetetraacetic acid ammonium salt (NH_4EDTA), or ethylenediaminetetraacetic acid diammonium salt ($(\text{NH}_4)_2\text{EDTA}$). As a non-limiting example, the metalloproteinase inhibitors may be ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid (EGTA) or a salt thereof, such as, for example, the tetrasodium salt, Na_4EGTA . Other non-limiting examples of metalloproteinase inhibitors include S,S'-ethylenediamine disuccinic acid (EDDS), 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid (CDTA) and N-(2-hydroxyethyl)ethylenediamine-N,N'-tri-acetic acid (HEEDTA). Still other non-limiting examples of metalloproteinase inhibitors include methylglycinediacetic acid (MGDA), N,N-bis(carboxymethyl)glutamate (GLUDA), ortho-phenanthroline, 8-hydroxyquinoline, and phosphonic acid derivatives such as amino-tris methylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 2", diethylene triamine pentamethylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Busperse 254", 2-phosphono-1,2,4-butanetricarboxylic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 9", hydroxyethylidene-diphosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 6", or a blend of 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), e.g., sold by Buckman Laboratories under the tradename "BPS 319." Still other examples of

metalloproteinase inhibitors include citric acid and salts of citric acid, gluconic acid, and salts of gluconic acid, cysteine, iodoacetic acid and sodium iodoacetate. Mixtures of any of the compounds named herein may also be used. The amount of the metalloproteinase inhibitor contained in the dipping or soaking solution is not critical and may be any amount effective to prevent or inhibit the putrefaction, degradation, and/or deterioration of the animal hides or skins in the composition. As an example, the amount of the metalloproteinase inhibitor in the dipping or soaking solution can be from about 0.00001% to about 10%, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight based on the weight of the animal skin or hide contained in the composition. Alternatively, the amount of the metalloproteinase inhibitor in the dipping or soaking solution can be from about 0.00001% to about 10%, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight based on the dipping or soaking solution. The dipping or soaking solution can be any solution, such as, for example, an aqueous solution, that is used to treat animal skins or hides, including, but not limited to cleaning, chilling, curing, pickling, liming and/or deliming solutions, and/or solutions for softening or hydrating an animal skin or hide.

[0034] The present invention further relates to an animal skin or hide having at least one metalloproteinase inhibitor applied to at least one surface thereof. The metalloproteinase inhibitor is as defined above and can be a chelator, such as a chelator of a divalent metal ion. As a non-limiting example, the metalloproteinase inhibitor may be an aminocarboxylic acid or a polyaminocarboxylic acid or a salt thereof. As a non-limiting example, the metalloproteinase inhibitor may be ethylenediaminetetraacetic acid (EDTA) or a salt thereof, such as, for example, ethylenediaminetetraacetic acid disodium salt (Na_2EDTA or disodium EDTA), ethylenediaminetetraacetic acid trisodium salt (Na_3EDTA or trisodium EDTA),

ethylenediaminetetraacetic acid tetrasodium salt (Na_4EDTA or tetrasodium EDTA), ethylenediaminetetraacetic acid dipotassium salt (K_2EDTA), ethylenediaminetetraacetic acid tripotassium salt (K_3EDTA), ethylenediaminetetraacetic acid ammonium salt (NH_4EDTA), or ethylenediaminetetraacetic acid diammonium salt ($(\text{NH}_4)_2\text{EDTA}$). As a non-limiting example, the metalloproteinase inhibitors may be ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid (EGTA) or a salt thereof, such as, for example, the tetrasodium salt, Na_4EGTA . Other non-limiting examples of metalloproteinase inhibitors include S,S'-ethylenediamine disuccinic acid (EDDS), 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid (CDTA) and N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid (HEEDTA). Still other non-limiting examples of metalloproteinase inhibitors include methylglycinediacetic acid (MGDA), N,N-bis(carboxymethyl)glutamate (GLUDA), ortho-phenanthroline, 8-hydroxyquinoline, and phosphonic acid derivatives such as amino-tris methylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 2", diethylene triamine pentamethylene phosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Busperse 254", 2-phosphono-1,2,4-butanetricarboxylic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 9", hydroxyethylidene-diphosphonic acid, e.g., sold by Buckman Laboratories under the tradename "Phos 6", or a blend of 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), e.g., sold by Buckman Laboratories under the tradename "BPS 319." Still other examples of metalloproteinase inhibitors include citric acid and salts of citric acid, gluconic acid, and salts of gluconic acid, cysteine, iodoacetic acid and sodium iodoacetate. Mixtures of any of the compounds named herein may also be used. The amount of the metalloproteinase inhibitor applied to the animal skin or hide is not critical and can be any amount effective to prevent or

inhibit the putrefaction, degradation, and/or deterioration of the animal skin or hide. As an example, the amount of the metalloproteinase inhibitor applied to the animal skin or hide can be from about 0.00001% to about 10%, preferably from about 0.0001% to about 5% and most preferably from about 0.001% to about 2% by weight based on the weight of the animal skin or hide. The metalloproteinase inhibitor may be rinsed off immediately or before tanning or may be left on the animal skin or hide.

[0035] In general, any treatment time for any of the above-discussed embodiments can be used. The treatment time is a variable and depends upon the method chosen to apply the inhibitor to the hides or skins. For instance, if it is incorporated into brine curing, the treatment time can be one hour to one day or longer, and when used for fresh hide preservation, the inhibitor can be added to the mixing drum and drummed for an hour or two or more. Essentially, the treatment times can vary from one minute to one hour, to six hours, to twenty-four hours, forty-eight hours, seventy-two hours, or longer, depending upon the concentration of inhibitor used and/or the amount of protection desired.

[0036] The following examples are given to illustrate the nature of the invention. It should be understood, however, that the invention is not to be limited to the specific conditions or details set forth in these examples.

EXAMPLES

Examples 1 and 2

[0037] Collagenase activity evaluation: Inhibition of collagenase from pure cultures of bacteria by disodium EDTA, trisodium EDTA, tetrasodium EDTA, tetrasodium EGTA and trisodium EDDS.

Method

[0038] Nutrient agar amended with Azocoll (a substrate made up of insoluble particles of collagen impregnated with a bright azo dye) was used as the test medium to study collagenase activity. The nutrient agar was prepared and autoclaved and then was cooled to 55°C. Azocol was added to give a final concentration of 0.5%. The inhibitors were added to petri dishes, and the nutrient agar-azocoll medium was added and carefully mixed to give the desired concentration of the inhibitor. Using a sterile spatula or cork-borer, the middle portion of each plate of about the size of a United States quarter, was scooped out. Fresh nutrient agar-azocoll medium containing no inhibitor was added to replace the scooped out portion of the plate. Two collagenase positive bacteria, *Pseudomonas fluorescens* (Example 1) and *Aeromonas salmonicida* (Example 2), which were isolated from putrefying hides, were used as the sources of collagenase. The bacteria were grown overnight on nutrient agar. A suspension of each culture was made in sterile water and used to inoculate the middle portion of each plate. The treated samples were incubated at 30°C and evaluated after 24 hours, 2 days and 7 days for collagenase activity and also for the growth of the bacteria. The test cultures secreted collagenase into the medium as they grew to degrade the collagen in the azocoll medium, and collagenase activity was determined by visual inspection of the clear zone around the bacteria. All % are by weight percent of the active ingredient.

The results are summarized in Tables 1 and 2:

Table 1: Anticollagenase activities of chemicals using *Pseudomonas fluorescens* as a source of collagenase (Example 1).

<u>Compound</u>	<u>Conc.</u>	<u>Growth/Days</u>			<u>Collagenase Activity/Days</u>		
		1	2	7	1	2	7
Na ₂ EDTA	0.38%	0	0	++	0	0	0
	0.25%	++	++	++	0	0	0
	0.2%	+++	+++	+++	0	0	0
	0.15%	+++	+++	+++	0	0	0
	0.1%	++++	++++	++++	0	0	0
	0.05%	++++	++++	++++	0	0	+
	0.025%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₃ EDTA	0.38%	+	+	+	0	0	0
	0.25%	++	++	+++	0	0	0
	0.15%	+++	+++	+++	0	0	0
	0.1%	++++	++++	++++	0	0	0
	0.05%	++++	++++	++++	0	+	+
	0.025%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₄ EDTA	0.5%	0	+	+++	0	0	0
	0.4%	+	++	+++	0	0	0
	0.3%	+++	+++	+++	0	0	0
	0.2%	+++	+++	+++	0	0	0
	0.1%	+++	+++	++++	0	0	0
	0.075%	++++	++++	++++	0	0	0
	0.05%	++++	++++	++++	0	0	0
	0.025%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₄ EGTA	0.5%	++++	++++	++++	0	0	0
	0.4%	++++	++++	++++	0	0	0
	0.3%	++++	++++	++++	0	0	0
	0.2%	++++	++++	++++	0	0	0
	0.1%	++++	++++	++++	0	0	0
	0.075	++++	++++	++++	0	0	0
	0.05%	++++	++++	++++	0	0	0
	0.025	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₃ EDDS	1.8%	++++ ^d	++++ ^e	++++ ^f	0 ^d	0 ^e	0 ^f
	1.5%	++++	++++	++++	0	0	0
	1.3%	++++	++++	++++	0	0	0
	1%	++++	++++	++++	0	0	0

0.9%	++++	++++	++++	0	0	0
0.8%	++++	++++	++++	0	0	0
0.7%	++++	++++	++++	0	0	0
0.6%	++++	++++	++++	0	0	+
0.5%	++++	++++	++++	0	0	++++
0.4%	++++	++++	++++	0	++	++++
0.3%	++++	++++	++++	0	+++	++++
0.2%	++++	++++	++++	+	++++	++++
0.1%	++++	++++	++++	++++	++++	++++
0%	++++	++++	++++	++++	++++	++++

Legend

^{d,e,f} Data was collected on days 2,3,and 7, respectively.

Growth: 0 = No growth
 + = Very Little growth
 ++ = Medium growth
 +++ = Heavy growth
 ++++ = Very heavy growth

Collagenase activity
 0 = No collagenase activity
 + = Very little collagenase activity
 ++ = Medium collagenase activity
 +++ = Strong collagenase activity
 ++++ = Very strong collagenase activity

Table 2: Anticollagenase activity of chemicals using *Aeromonas salmonicida* as a source of collagenase (Example 2).

<u>Compound</u>	<u>Conc.</u>	<u>Growth/Days</u>			<u>Collagenase Activity/Days</u>		
		1	2	7	1	2	7
Na ₂ EDTA	0.2%	++	+++	++++	0	0	0
	0.1%	++++	++++	++++	0	0	0
	0.05%	++++	++++	++++	++++	++++	++++
	0.025%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₃ EDTA	0.2%	+	+++	++++	0	0	0

	0.1%	+	++++	++++	0	0	0
	0.05%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++
Na ₄ EDTA	0.5%	0	+++ ^a	+++	0	0 ^a	0
	0.25%	0	+++ ^a	+++	0	0 ^a	0
	0.1%	0	+++ ^a	+++	0	0 ^a	0
	0%	++++	++++ ^a	++++	++++	++++ ^a	++++
Na ₄ EGTA	0.5%	++++	++++	++++	0	0	0
	0.25%	++++	++++	++++	0	0	0
	0.1%	++++	++++	++++	0	0	0
	0%	++++	++++	++++	++++	++++	++++
Na ₃ EDDS	2%	++	+++	+++	0	0	0
	1.8%	+++	++++	++++	0	0	0
	1.5%	++++	++++	++++	0	0	0
	1.3%	++++	++++	++++	0	0	+++
	1.2%	++++	++++	++++	0	+	++++
	1%	++++	++++	++++	0	++	++++
	0.7%	++++	++++	++++	0	++++	++++
	0.5%	++++	++++	++++	0	++++	++++
	0.2%	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++

Legend

Growth: 0 = No growth
 + = Very Little growth
 ++ = Medium growth
 +++ = Heavy growth
 ++++ = Very heavy growth

Collagenase activity

0 = No collagenase activity
 + = Very little collagenase activity
 ++ = Medium collagenase activity
 +++ = Strong collagenase activity
 ++++ = Very strong collagenase activity

^aData was collected on the fourth day.

[0039] As shown in Tables 1 and 2, the three EDTA salts, Na₄EGTA and Na₃EDDS

performed very well as collagenase inhibitors against collagenase produced by the bacteria studied. Further, the compounds were effective as collagenase inhibitors at concentrations that were well below what would be required to stop bacterial growth.

Example 3

[0040] Inhibition of collagenase from mixed bacteria growing on fresh hides by disodium EDTA, trisodium EDTA, tetrasodium EDTA, and tetrasodium EGTA.

Method

[0041] Nutrient agar amended with 0.5% AZOCOLL was used as the test medium to study collagenase activity. The nutrient agar was prepared and autoclaved and then was cooled to 55°C. Azocol was added to give a final concentration of 0.5%. The inhibitors were added to petri dishes, and the nutrient agar-azocoll medium was added and carefully mixed to give the desired concentrations of the inhibitor. Fresh hides were obtained from a tannery and were cut into pieces of approximately 2 cm square. One 2x2 cm hide sample was placed on top of the agar containing the inhibitors. Treated samples were incubated at 30° C and evaluated after 24 hours, 2 days , 3 or 4 days and 7 days for collagenase activity and also for the growth of the bacteria. The bacteria from the hides secreted collagenase into the medium as they grew to degrade the collagen in the azocoll medium and collagenase activity was determined by visual inspection of the clear zone around the bacteria

The results are summarized in Table 3

Table 3: Anticollagenase activities of chemicals using collagenase from mixed bacteria on fresh hide samples (Example 3).

<u>Compound</u>	<u>Conc.</u>	<u>Growth/Days</u>			<u>Collagenase Activity/Days</u>			
		1	2	4	1	2	4	7
Na ₂ EDTA	0.5%	0	+++	++++	0	0	0	0
	0.4%	0	+++	++++	0	0	0	0
	0.3%	0	+++	++++	0	0	0	+
	0.2%	0	+++	++++	0	0	0	+
	0.1%	++	++++	++++	0	+	+++	+++
	0.075	++++	++++	++++	+	+++	++++	++++
	0.05%	++++	++++	++++	0	+++	++++	++++
	0.025%	++++	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++	++++
Na ₃ EDTA	0.5%	++	++++	++++	0	0	0	+
	0.4%	++++	++++	++++	0	0	0	+
	0.3%	+++	+++	+++	0	0	+	++
	0.2%	++++	++++	++++	0	0	++	+++
	0.1%	++++	++++	++++	0	+	+++	+++
	0.075%	++++	++++	++++	0	+	+++	++++
	0.05%	++++	++++	++++	++	+++	++++	++++
	0.025%	++++	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++	++++
Na ₄ EDTA	0.5%	++++	++++	++++	0	0	***	++
	0.4%	++++	++++	++++	0	+	+	+++
	0.3%	++++	++++	++++	0	+	+	+++
	0.2%	++++	++++	++++	0	+	++	+++
	0.1%	++++	++++	++++	0	+	++	+++
	0.075%	++++	++++	++++	+	++	+++	++++
	0.05%	++++	++++	++++	++++	++++	++++	++++
	0.025%	++++	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++	++++
Na ₄ EGTA	0.5%	+++	++++	++++	0	0	0**	0
	0.4%	+++	++++	++++	0	0	0	+
	0.3%	++++	++++	++++	0	0	+	+
	0.2%	++++	++++	++++	0	0	+	+
	0.1%	++++	++++	++++	0	0	+	++
	0.075	++++	++++	++++	0	++	++++	++++
	0.05%	++++	++++	++++	++++	++++	++++	++++
	0.025	++++	++++	++++	++++	++++	++++	++++
	0%	++++	++++	++++	++++	++++	++++	++++

Legend

**** Data collected on Day 3.**

Growth: 0 = No growth
 + = Very Little growth
 ++ = Medium growth
 +++ = Heavy growth
 ++++ = Very heavy growth

Collagenase activity
 0 = No collagenase activity
 + = Very little collagenase activity
 ++ = Medium collagenase activity
 +++ = Strong collagenase activity
 ++++ = Very strong collagenase activity

[0042] The three EDTA salts and Na₄EGTA performed very well as collagenase inhibitors against collagenase produced by the mixed culture of bacteria from the hides. Further, the compounds were effective as collagenase inhibitors at concentrations that were well below what would be required to stop bacterial growth.

[0043] Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the present specification and practice of the present invention disclosed herein. It is intended that the present specification and examples be considered as exemplary only with a true scope and spirit of the invention being indicated by the following claims and equivalents thereof.

WHAT IS CLAIMED IS:

1. A method of preventing or inhibiting putrefaction, degradation, and/or deterioration of an animal skin or hide, the method comprising applying at least one metalloproteinase inhibitor in a solution to the animal skin or hide, or adding at least one metalloproteinase inhibitor to a fluid in which the animal skin or hide is dipped or soaked, or applying at least one metalloproteinase inhibitor to a solid surface that directly or indirectly comes into contact with the animal skin or hide.
2. The method of claim 1 wherein the at least one metalloproteinase inhibitor is a chelator of a divalent metal ion.
3. The method of claim 1 wherein the at least one metalloproteinase inhibitor is an inhibitor of a metalloproteinase produced by a microorganism.
4. The method of claim 1 wherein the at least one metalloproteinase inhibitor is a collagenase inhibitor.
5. The method of claim 1 wherein the at least one metalloproteinase inhibitor is an aminocarboxylic acid or polyaminocarboxylic acid or a salt thereof.
6. The method of claim 1 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid or a salt thereof or is ethylenediaminetriacetic acid or a salt

thereof.

7. The method of claim 1 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid, ethylenediaminetetraacetic acid disodium salt, ethylenediaminetetraacetic acid trisodium salt, ethylenediaminetetraacetic acid tetrasodium salt, ethylenediaminetetraacetic acid dipotassium salt, ethylenediaminetetraacetic acid tripotassium salt, ethylenediaminetetraacetic acid ammonium salt, ethylenediaminetetraacetic acid diammonium salt, or combinations thereof.

8. The method of claim 1 wherein the at least one metalloproteinase inhibitor is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid or a salt thereof.

9. The method of claim 1 wherein the at least one metalloproteinase inhibitor is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid tetrasodium salt .

10. The method of claim 1, wherein the at least one metalloproteinase inhibitor is S,S'-ethylenediamine disuccinic acid, 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid, N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid, methylglycinediacetic acid, N,N-bis(carboxymethyl)glutamate, ortho-phenanthroline, 8-hydroxyquinoline, amino-tris methylene phosphonic acid, diethylene triamine pentamethylene phosphonic acid, 2-phosphono-1,2,4-butanetricarboxylic acid, hydroxyethylidene-diphosphonic acid, 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), citric acid, a salt of citric acid, gluconic acid, a salt of gluconic acid, cysteine, iodoacetic acid or

sodium iodoacetate or combinations thereof.

11. The method of claim 1 wherein the at least one metalloproteinase inhibitor is applied to the animal skin or hide in an amount of from about 0.00001% to about 10% by weight based on the animal skin or hide.

12. The method of claim 1 wherein the metalloproteinase inhibitor is applied to the animal skin or hide in an amount of from about 0.0001% to about 5% by weight based on the animal skin or hide.

13. The method of claim 1 wherein the at least one metalloproteinase inhibitor is applied to the animal skin or hide in an amount of from about 0.001% to about 2% by weight based on the animal skin or hide.

14. The method of claim 1 wherein the at least one metalloproteinase inhibitor is applied to the animal skin or hide in a solution by spraying.

15. The method of claim 1 wherein the at least one metalloproteinase inhibitor is applied to a fluid that contacts the animal skin or hide so that the at least one metalloproteinase is present in fluid that contacts the animal skin or hide in an amount of from 0.00001% to about 10% by weight of the fluid.

16. The method of claim 1 wherein the at least one metalloproteinase inhibitor is applied to a

surface that contacts the animal skin or hide by combining the at least one metalloproteinase inhibitor with a fluid medium to form a mixture and applying the mixture to the surface, wherein the at least one metalloproteinase is present in the mixture in an amount of from 0.00001% to about 10% by weight of the mixture.

17. A method of preventing or inhibiting putrefaction, degradation, and/or deterioration of an animal skin or hide, the method comprising applying at least one polyaminocarboxylic acid, or a salt thereof, in a solution to the animal skin or hide, or adding at least one polyaminocarboxylic acid, or a salt thereof, to a fluid in which the animal skin or hide is dipped or soaked, or applying at least one polyaminocarboxylic acid, or a salt thereof, to a solid surface that directly or indirectly comes into contact with the animal skin or hide.

18. The method of claim 17 wherein the at least one polyaminocarboxylic acid is ethylenediaminetetraacetic acid or a salt thereof or is ethylenediaminetriacetic acid or a salt thereof.

19. The method of claim 17 wherein the at least one polyaminocarboxylic acid is ethylenediaminetetraacetic acid, ethylenediaminetetraacetic acid disodium salt, ethylenediaminetetraacetic acid trisodium salt, ethylenediaminetetraacetic acid tetrasodium salt, ethylenediaminetetraacetic acid dipotassium salt, ethylenediaminetetraacetic acid tripotassium salt, ethylenediaminetetraacetic acid ammonium salt, or ethylenediaminetetraacetic acid diammonium salt.

20. The method of claim 17 wherein the at least one polyaminocarboxylic acid is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid or a salt thereof.
21. The method of claim 17 wherein the at least one polyaminocarboxylic acid is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid tetrasodium salt.
22. The method of claim 1, wherein the at least one metalloproteinase inhibitor is S,S'-ethylenediamine disuccinic acid, 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid, N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid, methylglycinediacetic acid, N,N-bis(carboxymethyl)glutamate, ortho-phenanthroline, 8-hydroxyquinoline, amino-tris methylene phosphonic acid, diethylene triamine pentamethylene phosphonic acid, 2-phosphono-1,2,4-butanetricarboxylic acid, hydroxyethylidene-diphosphonic acid, 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetakis (methylene phosphonic acid), citric acid, a salt of citric acid, gluconic acid, a salt of gluconic acid, cysteine, iodoacetic acid or sodium iodoacetate or combinations thereof.
23. The method of claim 17 wherein the at least one polyaminocarboxylic acid is applied to the animal skin or hide in an amount of from about 0.00001% to about 10% by weight based on the animal skin or hide.
24. The method of claim 17 wherein the polyaminocarboxylic acid is applied to the animal skin or hide in an amount of from about 0.0001% to about 5% by weight based on the animal skin or hide.

25. The method of claim 17 wherein the at least one polyaminocarboxylic acid is applied to the animal skin or hide in an amount of from about 0.001% to about 2% by weight based on the animal skin or hide.

26. A method of producing leather comprising steps of detaching an animal skin or hide from a slaughtered animal, curing the animal skin or hide, soaking the cured animal skin or hide, removing flesh and hair from the soaked animal skin or hide, and tanning the animal skin or hide from which the flesh and hair has been removed to form leather, wherein after the step of detaching the animal skin or hide from the slaughtered animal and before the step of tanning the animal skin or hide from which the flesh and hair has been removed to form leather, a solution comprising at least one metalloproteinase inhibitor is applied to the animal skin or hide in a sufficient amount to prevent or inhibit putrefaction, degradation, and/or deterioration of the animal skin or hide.

27. A composition comprising a dipping or soaking solution having at least one animal skin or hide dipped or soaked therein, wherein the dipping or soaking solution contains at least one metalloproteinase inhibitor.

28. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is a chelator of a divalent metal ion.

29. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is an

inhibitor of a metalloproteinase produced by a microorganism.

30. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is a collagenase inhibitor.

31. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is an aminocarboxylic acid or polyaminocarboxylic acid or a salt thereof.

32. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid or a salt thereof or is ethylenediaminetriacetic acid or a salt thereof.

33. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid, ethylenediaminetetraacetic acid disodium salt, ethylenediaminetetraacetic acid trisodium salt, ethylenediaminetetraacetic acid tetrasodium salt, ethylenediaminetetraacetic acid dipotassium salt, ethylenediaminetetraacetic acid tripotassium salt, ethylenediaminetetraacetic acid ammonium salt, ethylenediaminetetraacetic acid diammonium salt, or combinations thereof.

34. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is ethylene glycol-bis(β -aminoethylether)-N,N,N'N'-tetraacetic acid or a salt thereof.

35. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is

ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid tetrasodium salt .

36. The composition of claim 27, wherein the at least one metalloproteinase inhibitor is S,S'-ethylenediamine disuccinic acid, 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid, N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid, methylglycinediacetic acid, N,N-bis(carboxymethyl)glutamate, ortho-phenanthroline, 8-hydroxyquinoline, amino-tris methylene phosphonic acid, diethylene triamine pentamethylene phosphonic acid, 2-phosphono-1,2,4-butanetricarboxylic acid, hydroxyethylidene-diphosphonic acid, 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), citric acid, salt of citric acid, gluconic acid, salt of gluconic acid, cysteine, iodoacetic acid or sodium iodoacetate or combinations thereof.

37. The composition of claim 27 wherein the at least one metalloproteinase inhibitor is contained in the dipping or soaking solution in an amount of from about 0.00001% to about 10% by weight based on the at least one animal skin or hide dipped or soaked therein.

38. The composition of claim 27 wherein the dipping or soaking solution is a cleaning solution.

39. The composition of claim 27 wherein the dipping or soaking solution is a chilling solution having a temperature above freezing and below room temperature.

40. The composition of claim 27 wherein the dipping or soaking solution is a curing or

pickling solution.

41. The composition of claim 27 wherein the dipping or soaking solution is a liming solution.
42. The composition of claim 27 wherein the dipping or soaking solution is a deliming solution.
43. The composition of claim 27 wherein the dipping or soaking solution is a solution that softens or hydrates the animal skin or hide.
44. A composition comprising an animal skin or hide having a solution containing at least one metalloproteinase inhibitor applied to at least one surface thereof.
45. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is a chelator of a divalent metal ion.
46. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is an inhibitor of a metalloproteinase produced by a microorganism.
47. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is a collagenase inhibitor.
48. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is an

aminocarboxylic acid or polyaminocarboxylic acid or a salt thereof.

49. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid or a salt thereof or is ethylenediaminetriacetic acid or a salt thereof.

50. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is ethylenediaminetetraacetic acid, ethylenediaminetetraacetic acid disodium salt, ethylenediaminetetraacetic acid trisodium salt, ethylenediaminetetraacetic acid tetrasodium salt, ethylenediaminetetraacetic acid dipotassium salt, ethylenediaminetetraacetic acid tripotassium salt, ethylenediaminetetraacetic acid ammonium salt, ethylenediaminetetraacetic acid diammonium salt, or combinations thereof.

51. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid or a salt thereof.

52. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is ethylene glycol-bis(β -aminoethylether)-N,N,N',N'-tetraacetic acid tetrasodium salt.

53. The method of claim 44, wherein the at least one metalloproteinase inhibitor is S,S'-ethylenediamine disuccinic acid, 1,2-diaminocyclohexene-N,N,N',N'-tetraacetic acid, N-(2-hydroxyethyl)ethylenediamine-N,N'-triacetic acid, methylglycinediacetic acid, N,N-bis(carboxymethyl)glutamate, ortho-phenanthroline, 8-hydroxyquinoline, amino-tris methylene

phosphonic acid, diethylene triamine pentamethylene phosphonic acid, 2-phosphono-1,2,4-butanetricarboxylic acid, hydroxyethylidene-diphosphonic acid, 2-methylpentanediamine tetrakis (methylene phosphonic acid) and 1,2, diaminocyclohexanetetrakis (methylene phosphonic acid), citric acid, a salt of citric acid, gluconic acid, a salt of gluconic acid, cysteine, iodoacetic acid or sodium iodoacetate or combinations thereof.

54. The composition of claim 44 wherein the at least one metalloproteinase inhibitor is present on the surface of the animal skin or hide in an amount of from about 0.00001% to about 10% by weight based on the weight of the animal skin or hide.

55. A method of preventing or inhibiting putrefaction, degradation, and/or deterioration of an animal skin or hide, the method comprising applying at least one metalloproteinase inhibitor to the animal skin or hide, wherein the at least one metalloproteinase inhibitor is not admixed with a solid extender or carrier material.