Hypochlorous Acid

Livestock

Identification of Petitioned Substance

Chemical Names: Hypochlorous acid, hypochloric(I) acid, chloranol, hydroxidochlorine

Other Name: Hydrogen hypochlorite, Chlorine hydroxide

Trade Names: Oculus Puracyn Antimicrobial Skin and Wound Cleanser, Vashe® Wound Therapy Solution (OTC use), Vashe® Wound Therapy Solution (Professional use), NixallTMWound and Skin Care (OTC and Professional use), Excelyte VET, Clean Smart, FloraFresh® Floral Quality Care Solution, HSP2O Pro Disinfectant

CAS Numbers: 7790-92-3

Other Codes: European Community Number-22757, IUPAC-Hypochlorous acid

List other codes: PubChem CID 24341

InChI Key: QWPPOHNGKGFGJK-UHFFFAOYSA-N

UNII: 712K4CDC10

Summary of Petitioned Use

A petition was received by the National Organic Program (NOP) requesting the addition of hypochlorous acid (HOCl) generated from electrolyzed water to section 205.603 of the National List: synthetic substances allowed for use in organic livestock production. HOCl is petitioned for use as a disinfectant, and medical and topical treatments for organic livestock production. Direct HOCl contact with animals is requested. HOCl is the active ingredient in commercial veterinary and farm products used for wound care, post milking teat sanitation, dermatological disease and the treatment of eye irritation.

Recently, the National Organic Standards Board (NOSB) considered a petition to allow HOCl from electrolyzed water for use in organic crop and livestock production and handling and passed three separate recommendations for its addition to the National List in sections 205.601(a)(2), 205.603(a)(7) and 205.605(b). In a memorandum responding to this recommendation, NOP indicated its intent to move forward with a proposed rule for public comment to add HOCl to the National List. At the time of this report, a proposed rule has not yet been published. While these sections apply to the use of chlorine materials including HOCl respectively in crops for preharvest use and sprout production, in livestock for disinfecting and sanitizing facilities and equipment and in handling for disinfecting and sanitizing food contact surfaces where residual chlorine remains below the maximum residual disinfectant limit, currently 4 milligrams/liter, the previous NOSB recommendations did not consider the direct contact of HOCl with organic livestock(US NOP, 2015).

This limited scope technical evaluation report requested by the NOSB will both supplement information contained in a previous technical evaluation report and provide additional information pertaining to the use of HOCl in direct contact with livestock for organic production, specifically its use for the treatment of keratoconjunctivitis (pinkeye) and wounds.

Characterization of Petitioned Substance

Composition of the Substance:

HOCl is an oxyacid of chlorine containing monovalent chlorine that acts as an oxidizing or reducing agent (NCBI, 2017). A 2015 technical report on HOCl (handling/processing uses) is available at the NOP Petitioned Substances Database. HOCl is a chlorine releasing agent. It is one of three forms of aqueous chlorine: chlorine gas (Cl_2), HOCl and hypochlorite ion (OCl^-). Mostly HOCl is present in aqueous solutions pH between 2 - 7.5 at 25°C (Kettle et al., 2014).

Source or Origin of the Substance:

HOCl is produced by electrolyzing a brine solution made with purified water and sodium chloride. In general, the brine is submitted to direct electrical current as it flows through a cell that allows the physical separation of solutions around the positive and negative electrodes. Separation is usually achieved with a semi-permeable membrane. At pH 3.5 – 6.5 (30°C), greater than ninety percent of the chlorine species present at the anode is HOCl. If the flow cell is constructed properly HOCl can be removed from the anodic compartment as it is produced. Sodium hydroxide produced at the cathode is separately removed.

Dakin's solution, a solution containing a low concentration of sodium hypochlorite (household bleach), boric acid and sodium bicarbonate was adopted in the early 1900s and is still used as an effective microbiocide and disinfectant for burns and wounds (Dakin, 1915a,b). HOCl at a concentration of 0.3 percent is the predominant chlorine releasing agent present in Dakin's solution. Dakin's solution is not produced electrolytically. It is effective in killing *Staphylococcus* spp., *Streptococcus* spp. and *E. coli* (Smith et al., 1915). The effectiveness of Dakin's solution and the presence of HOCl is pH dependent. Although Dakin's solution is not produced from electrolyzed water, it is still a source of pure HOCl.

Properties of the Substance:

There is a pH and temperature dependent equilibrium between the three aqueous chlorine species, Cl_2, OCl^- and HOCl. This relationship for selected values of pH and temperature is shown for HOCl and OCl- (Table 1). Of the three aqueous species, HOCl is the primary bactericidal agent (White, 1972). As the pH increases the percentage of HOCl decreases with an increase in the percentage of OCl^-. With increasing ionic strength, the percentage of HOCl present in solution also decreases. At pH 7.5, with other ions such as phosphate present in solution the amount of HOCl in solution can be as low as 51%, balanced by 49% OCl^- (White, 2011).

Table 1 Percentage of chlorine present as HOCl as a function of pH and temperature (assuming zero ionic strength and considering HOCl and OCl^- as the only chlorine species present)

pH	Percent HOCl						
	0°C	5°C	10°C	15°C	20°C	25°C	30°C
5.0	99.85	99.82	99.80	99.77	99.74	99.71	99.68
5.5	99.53	99.45	99.36	99.27	99.18	99.09	99.00
6.0	98.53	98.27	98.00	97.72	97.45	97.18	96.92
6.5	95.48	94.72	93.94	93.14	92.35	91.58	90.86
7.0	86.99	85.02	83.05	81.11	79.24	77.48	75.86
7.5	67.89	64.23	60.78	57.59	54.69	52.11	49.84
8.0	40.06	36.21	32.89	30.04	27.63	25.60	23.91
8.5	17.45	15.22	13.42	11.95	10.77	9.81	9.04
Adapted from Black and Veatch Corporation, 2011							

Specific Uses of the Substance:

HOCl is the active microbiocidal ingredient in a number of veterinary preparations used for treatment of infectious keratoconjunctivitis (pinkeye), burns, wounds and mastitides. Keratoconjunctivitis is an inflammation of the covering membrane of the eye, including the orbit and the inner surface of the eyelids. This inflammation typically extends below the conjunctival layer (Farley, 1941). There are several causative agents. In cattle the most significant cause is the bacterium *Moraxella bovis*, and to a lesser extent *Chlamydia spp.*, *Neisseria catarrhalis*, and *Mycoplasm spp.* In sheep, the causes are *Rickettsia conjunctivae*, *Neisseria catarrhalis*, *Mycoplasma conjunctivae*, *Acholeplasma oculi* and *Chlamydia spp.* In goats, the cause is *Rickettsia conjunctivae*. In pigs, the cause is *Rickettsia spp.* In horses, the cause is frequently viral, but bacteria such as *Moraxella spp.* have been found associated with the inflammation (Radostits et al., 1994). Treatments that include HOCl are solutions, washes, teat dips and gels. They may be buffered or osmotically balanced. HOCl is used at a relatively low concentration in these treatments, 0.01-0.02%.

<u>Approved Legal Uses of the Substance:</u>

Veterinary HOCl solutions are regulated by the US Food and Drug Administration (FDA) through the premarket notification or 510 (k) programs. The procedure for 510 (k) submission is listed at §21 CFR 807.21. The 510(k) is a manufacturer's self-certification of the safety and efficacy of the product that otherwise does not require licensing. The FDA reviews and evaluates the product and determines 1) that a premarket approval is necessary or 2) that a premarket approval is not required. After the determination is made a letter is sent to the applicant allowing the product to be marketed. Solutions of hypochlorous acid for use in treatment of eye irritation and wound care are already legally marketed. New products such as those mentioned in the petition are considered substantially equivalent by the FDA and do not require premarket approval.

A petition has been received by the USDA to add veterinary HOCl solutions for organic livestock production to the National List.

<u>Action of the Substance:</u>

Neutrophils are white blood cells involved in the mammalian antibacterial immune response. They contain an enzyme called myeloperoxidase that reacts with hydrogen peroxide also produced by the neutrophil at sites of bacterial infection. Myeloperoxidase catalyzes the formation of hypohalous acids from hydrogen peroxide (Mika and C, Guruvayoorappan, 2011). HOCl is the major product. It is antimicrobial in vitro, although the actual antimicrobial process requires the conversion of HOCl to chloramine T which serves as the antimicrobial reactive oxidative species. Chloramine T forms when HOCl reacts with amine groups (Amulic et al., 2012).

HOCl rapidly kills the causative agents of infectious keratoconjunctivitis, wound infections and mastitides (Gard et al. 2012; Amulic et al., 2012). In addition to its microbiocidal effect, HOCl can have an anti-inflammatory effect by 1) reducing histamine activity, 2) reducing leukotriene activity, 3) increasing TGF-beta activity, 4) increasing growth factor synthesis and 5) decreasing metalloprotease 7, collagenase and gelatinase activity (Pelgrift and Friedman, 2013).

<u>Combinations of the Substance:</u>

Commercially available treatments contain products from the production of electrolyzed water, including sodium chloride (NaCl), HOCl and sodium hypochlorite, but may also contain added pH buffers such as sodium phosphate (NaH_2PO_4/ Na_2HPO_4), sodium sulfate and sodium bicarbonate, and colloidal gels such as lithium magnesium sodium silicate depending upon the tissue to be treated. A teat dip product that releases HOCl consists of two dissolved 2.5 g sodium dichloroisocyanuarate tablets dissolved in one liter of water with an available chlorine concentration of 2800 ppm at pH 5.5-6.0 (Bodie et al., 1995).

Limited Scope Questions for Hypochlorous Acid to be Used Livestock Production

For this limited scope report, the NOSB Livestock Subcommittee has requested that the report respond to the specific questions listed below.

<u>Evaluation Question #1:</u> What is the efficacy of hypochlorous acid for pinkeye and wound treatment, relative to other products (both synthetic and on the National List)?

HOCl is available in several commercial presentations for veterinary treatment of pink eye and wounds. A number of studies with these preparations have shown the efficaciousness of HOCl for pinkeye, wounds, burns and mastitides (Gard et al., 2016; Pegrift and Friedman, 2013; Hua et al., 2003). In addition to HOCl and hypochlorite, these products can contain sodium phosphate or silicate in the case of colloidal burn treatments. HOCl and hypochlorite salts are not currently on the National List for treatment of pink eye and wounds. Sodium phosphates and aqueous potassium silicate are approved for use respectively in organic handling (§205.605(b) and crop production (§205.601(e)(2)). Sodium phosphate or sodium silicate may be allowed as excipients if their use complies with the requirements at section 205.603(f).

HOCl is a chlorine releasing agent (CRA). It is considered the active moiety responsible for bacterial inactivation by CRAs. CRA microbiocidal activity is greatest when the percentage of undissociated HOCl is highest. At a concentration of 50 micromoles (μM)/liter (l) (2.6 ppm), HOCl produces deleterious effects on bacterial DNA resulting in the formation of chlorinated derivatives of nucleotide bases and complete inhibition of *Escherichia coli* growth. Concentrations greater than 5 millimoles/l (260 ppm) have been found to disrupt oxidative phosphorylation and other membrane-associated activity (McDonnell and Russell, 1999).

The primary cause of infectious bovine keratoconjunctivitis (pinkeye) is the bacteria *Moraxella bovis*. It is a gram negative, aerobic, oxidase positive diplococcus (Holt, 1994). The bacterial pili and the enzyme hemolysin have both been established in disease pathogenesis. The pili help to attach bacteria to the cornea, while hemolysin is linked to cell membrane disruption. In addition, the host immune response against the bacteria can be prolonged due to an immunoevasive process called phase variation. Phase variation permits the bacterial to rearrange its genes for pilus formation producing a changing immune signature for the largest bacterial organelle. Without a solid short term, immune response from the animal pinkeye can be exacerbated and prolonged (Marrs et al., 1988). Vaccines used for pink eye must contain all of the variant pilus types to be effective, thus many bacterins or killed vaccines commonly used in organic production are not always effective (McConnell et al., 2008; O'Conner et al., 2011). However, without other treatment options, many organic producers still choose to vaccinate. Vaccines are on the National List at section 205.603(a)(4) as "Biologics – Vaccines."

A commercial veterinary spray treatment containing 0.009% HOCl, sodium chloride and phosphate buffer was examined by a group at Auburn University. The study consisted of thirty calves randomized into three groups. In groups one and two a corneal lesion was also induced into the left eye and the same eye was then infected with *Moraxella bovis* to induce pinkeye. The right eye of these two groups served as a control. No corneal lesion was induced. Nor was it infected with *M. bovis*. A third group did not receive a corneal lesion in either eye, but was inoculated with *M. bovis* in the left eye. Beginning 24 hours after inoculation with *M. bovis*, calves in group 1 were treated with 0.009% HOCl for a total of 2 milliliters per application (3 sprays) twice daily for ten days. Calves in group 2 were treated 24 hour post *M. bovis* inoculation with 0.9% sterile saline solution for a total of 2 milliliters per application (3 sprays) twice daily for ten days. Following inoculation with *M. bovis*, calves in group three were not treated. Both eyes in all three groups were evaluated for evidence of pain and ocular discharge associated with the clinical signs of infectious bovine keratoconjunctivitis (IBK) throughout the study. In addition, blood and liver biopsy samples were collected to determine if chlorine levels increased internally. All calves in groups one and two developed corneal ulcerations and clinical signs consistent with IBK in the left eye. No clinical signs were observed at any time during the study in group three or the right eye of groups one and two. After ten days, all of the animals in groups one and three were culture negative for *M. bovis*. Average healing time of corneal lesions was 3.7±1.2 days for group one and 8.3±3.7 for group 2 ($p<0.0002$). In this study, topical ophthalmic application of HOCl was effective in treating experimentally induced pinkeye. No additional chlorine accumulated internally in any of the test animals. Pain experienced by the calves as a result of the pinkeye infection was also much less in the group treated with HOCl (Gard et al., 2016).

There are a number of studies in both human and rat showing positive results for healing and pain relief from the use of HOCl solutions for debridement and maintenance of burns and wounds (Selkon et al., 2006; Liden, 2013; Robson, 2007; Nakae and Inaba, 2000; Hua et al., 2003; Sakarya et al., 2014). In the case of colorectal surgery, however; in which no significant difference was observed between using HOCl and saline, HOCl is not recommended (Takesue et al., 2011). When used for veterinary wound treatment, solutions containing a low concentration (0.11-0.12 %) of HOCl produced either by electrolysis of water or dilution of sodium hypochlorite (Dakin's solution) provided a reduction in bacterial infection and improved wound healing (Krahwinkel and Boothe, 2006; Ramey and Kinde, 2015).

During wound healing, there is a pH shift from acidic, which is the pH of normal skin to slightly alkaline, resulting from the myriad of biochemical reactions facilitating degradation of dead tissue, the intercalation of the wound with new structures of extracellular matrix and the reassembly of connective tissue and epithelium (Schnieder et al., 2007). The intervention of phagocytic white blood cells (neutrophils) during this process includes the release of a chlorine to kill bacteria and fungi. An acidic pH adjustment also occurs during this particular step which favors myeloperoxidase mediated production of the chlorine releasing agent, HOCl (Pullar et al., 2000). Cellular antioxidants are produced to control excessive HOCl production and prevent tissue damage (Mika and Guruvayoorappan C, 2011).

Evaluation Question #2: What items are being used for pink eye and wound treatment on organic farms?

Face flies are known to carry and transmit the bacteria *Moraxella bovis*, the etiological agent for infectious bovine keratoconjunctivitis (Berebile and Webber, 1981; OConnor et al., 2012). Controlling flies helps to reduce the risks of disease spread between animals in a herd. The face fly, *Musca autumnalis* (Diptera: Muscidae), feeds at the eyes and faces of cattle and horses in the temperate regions of the northern hemisphere. Feeding flies probe with their proboscis and consume secretions or discharges from their hosts' eyes, nostrils, mouths, vulvae, teats, and other body parts. Sharp spines surrounding the fly's mouth may cause superficial lesions increasing the likelihood of infection. Eggs and larvae occur exclusively in the dung pats of cattle and bison (Krafsur and Moon, 1997). Pinkeye was enzootic in North America before the face fly was introduced, but its prevalence has increased since the fly arrived. Face fly abundance correlates positively with disease incidence (Hall, 1984). Face flies are attracted to a number of substances including cattle fed a diet of alfalfa (Pickens and Miller, 1980). Vespid wasps such as *Vespula germanica* (Fabricius) have been identified as a predator of face flies. These and other predatory wasps can also be used to control maggot fly larvae in dung (Schidtmann, 1977; Skovgard, 2004). Ground phosphate rock can be scattered over gutter manure and manure heaps to destroy fly larva (Surface, 1915). Fly traps can be used for removal of flies from the animals or their housing (Denning et al, 2014; Kaufman et al., 2005). Other organic production methods for fly control can include the use of cow masks, cleaning out box stall buildup (especially the near the corners), having chickens peck away the manure paddies after animals have been through a paddock and/or having hogs root through the paddies. Frequent applications of extracts, and essential oils as well as sulfur dusting may also provide some relief (An M.R.C.V.S., 1915).

Flies are generally more numerous in tall grass. Trimming tall grass, and foxtails can serve to reduce fly populations (Bersford and Sutcliffe, 2008). Trimming tall grass also help to prevent scratches to the eyes of feeding animals. Reducing moisture in the animal's environment helps to reduce fly numbers. Sprinkling field lime or diatomaceous earth on the animals helps to keep them dry. Because pinkeye is infectious affected animals should be separated if possible. However, in some cases, *M. bovis* may infect animals in a carrier state where no clinical signs appear, but the animal remains infectious and bacterial transmission is possible. Here diagnosis is important.

Topical treatment is recommended for both pinkeye and wounds. Repeated and frequent applications of various combinations of isotonic saline solution, calendula, garlic, echinacea, cochlearia, honey (wounds), sugar (wounds), essential oils, eyebright, goldenseal, colloidal silver, breast milk cod liver oil, *Aloe vera* and coconut oil have been used as washes and topical treatments (Zinke, 2010; Menendez et al., 2007; Swaim and Lee, 1987). Many of these substances are microbiocidal and serve to kill or control the bacterial infection (Calvo and Czvero, 2016). For pinkeye, anything that soothes the eye is also helpful. Dairy cattle and calves are generally easier to treat, since restraint may be required for application. No one method is preferable and efficacy is not assured. In the case of wounds, and in addition to washing the wound, disinfection is generally indicated (Krahwinkel and Boothe, 2006).

Kelp meal is often fed to organic dairy cattle serving as a mineral and vitamin source (Hardie et al., 2014)). In addition, vitamins A, D, and E are helpful in maintaining the livestock immune system and eye health (Anonymous, 1976). Adequate levels of trace minerals such as copper and selenium are also indicated for a properly functioning immune system. Because sunlight and ultraviolet light aggravates pinkeye, animals should be sequestered from sunlight and ultraviolet. It is best to let them out at night for grazing if this is possible.

As of April 5, 2017, seven licensed *M. bovis* bacterin vaccines, one conditionally licensed *M. bovoculi* bacterin vaccine, three combination bacterin-toxoid vaccines containing *M. bovis*, one M. bovis bacterin for further manufacture and one *M. bovis* killed culture for further manufacture are listed in the USDA Animal Plant Health Inspection Service's USDA Veterinary Biological Products. These are also listed in Table 2.

Bacterins are normally acceptable for use in Organic Livestock Production. Bacterins are simply bacteria killed with formaldehyde. The formaldehyde is dried off, and an adjuvant is added to stimulate the immune response. Bacteria used for the bacterin may be a naturally occurring isolate or it may be genetically modified. Because M. bovis exhibits phase variation, several isolates are combined into the vaccine to cover possible immune variation. Furthermore, M. bovoculi was recently recognized as an additional causal bacterium for bovine pinkeye. A vaccine for this M. bovoculi is now also available (OConnor et al., 2012). Vaccines are a useful tool for reducing production losses (McConnel et al., 2008). However, the highly variable immunogenic profile of *M. bovis* has complicated the use of vaccines. Many producers use them, but they do not always work. Even a vaccine produced from isolates from the same farm where it was used was not very efficacious, raising a concern that even autogenous vaccines are often ineffective in controlling naturally occurring IBK (OConnor et al., 2011). Vaccinations should be administered well in advance (ideally at least four weeks) of the anticipated summer onset of pinkeye, so that cattle will have enough time to mount an effective immune response following vaccination. Young animals tend to be most affected, and should be a part of the vaccination program.

Table 2 Vaccines for Infectious Bovine Keratoconjunctivitis

Type of Vaccine	USDA Vaccine Code	Producer	Description
Moraxell bovis bacterin	2772.00	1, 2, 3, 4	Formaldehyde inactivated, multiisolate bacterin. Contains an adjuvant to stimulate the immune response. Different isolates, numbers of isolate, adjuvants, etc.
	2772.03	5	
	2772.04	5	
	2772.10	6	
Moraxella bovoculi bacterin	2A77.00	4	For pinkeye caused by *M. boviculi*
Clostridium Chauvoei-Septicum-Novyi-Sordellii-Perfringens Types C & D-Moraxella Bovis Bacterin-Toxoid	7425.01	1	Multi valent bacterin-toxoid vaccine, contains *M. bovis* bacterin.
	7425.02	5	
	7425.03	5	
Moraxell bovis bacterin	B772.00	4	for further manufacture
Moraxell bovis killed culture	B772.01	4	

[1]Boehringer Ingelheim Vetmedica, Inc., Divisions: Bio-Ceutic, Anchor, 2621 North Belt Highway, St. Joseph, MO 64506 (124, 124A)

[2] Elanco US Inc. 196, Subsidiaries: Lohmann Animal Health International, Elanco US Inc., 1447 140th Street, Larchwood, IA 51241, 196

[3] Novartis Animal Health US, Inc., 1447 140th Street, Larchwood, IA 51241-9778 303

[4] Addison Biological Laboratory, Inc., Route 3 Box 90-B, Fayette, MO 65248 355

[5] Intervet Inc. 165A, Divisions: Merck Animal Health, Merck Sharpe and Dohme (MSD), 21401 West Center Road, Elkhorn, NE 68022

[6] SolidTech Animal Health, Inc. 604, 812 NE 24th Street, P.O. Box 790, Newcastle, OK 73065-0790

Hair color, age, host behavior such as comparisons of movement, grazing and lying down and aggregation of host animals have been reported to influence cattle-host selection by face flies and predilection for pinkeye. Breeds which lack pigment on their eyelids (Herefords, Hereford crosses, Charolais and some Holsteins) are hypothesized to be more susceptible to pinkeye than dark-hided cattle. Although lighter hair and eye color suggests more susceptibility, hair color and eye pigment are likely not to be the only selective criteria. The breed that appears to be most susceptible to face flies and pinkeye is the Hereford. While tropically adapted breeds such as Brahmin are less susceptible. (Steelman et al., 1993, Snowder et al., 2005).

Genetic tracking of breed susceptibility to pinkeye has followed the quantitative trait locus (QTL). A QTL is a section of genetic information (DNA) on a chromosome (the locus) in the genome that correlates with variation in a phenotype (the quantitative trait). Usually the QTL is nearby on the chromosome, or contains, the genes that control the specific phenotype. QTLs are mapped by identifying the molecular biomarkers correlated with an observed trait. This is sometimes an early step in identifying and sequencing the actual genes that cause the trait variation (Miles and Wayne, 2008). QTLs have been identified for infectious bovine keratoconjunctivitis (IBK) on chromosome 1 and 20 associated with the probability of contracting this disease (Casa and Stone, 2006). The QTL on chromosome 1 may have a link to the bovine macrophage activity, while the QTL on chromosome 20 may be associated with the cellular or non-specific immune response (Garcia et al., 2010; Casa and Stone, 2008).

Wound care begins with direct pressure to the wounded site. This helps to stop the bleeding. Ice also constricts vessels and will slow bleeding. Irrigation with saline, dilute disinfectant or water is next to wash away contamination including bacteria and stimulate healing. Both iodine and chlorhexidine are allowed for use as disinfectants when other disinfection methods are not expected to work. Iodine is allowed for use as a disinfectant and a topical treatment. Aqueous iodine is antibacterial, but at higher concentration is deleterious to tissues *in vivo* and may potentiate infection. Iodine is more effective at lower concentrations, 0.1% or 1%, rather than the 10% solution that is normally supplied (Swaim and Lee, 1987). Chlorhexidine is allowed for surgical procedures conducted by a licensed veterinarian. Chlorhexidine is an effective antimicrobial. Wounds irrigated with 0.1%, 0.25% or 1% chlorhexidine did better than wounds respectively irrigated with 0.1%, 0.25% and 0.5% iodine and polyvinylpyrrolidone. However, a correlation between chlorhexidine use and joint inflammation has been noted. Although not approved for organic use, Dakin's solution, a dilute sodium hypochlorite solution (0.005%) has been found to be more effective at killing *Staphyloccus aureus* than chlorhexidine (Swain and Lee, 1987). Externally copper sulfate is antiseptic, astringent, caustic germicidal, fungicidal and viricidal. It can be used in solution for wound debridement and applied as a powder to wounds and as an antiseptic post surgical treatment (Mouli, 2005). Ringer's solution is effective for wound debridement and some relief from pain (Colegrave et al., 2016). Ringer's solution typically contains sodium chloride, potassium chloride, calcium chloride and sodium bicarbonate, with the last used to balance the pH.

<u>Evaluation Question #3:</u> What natural items could be used?

Natural items are products that come from plants, animals, or minerals. There are many remedies that have not been experimentally tested. Several organically produced combinations are available commercially. Table 3 provides a non-exhaustive list of known natural products that may be used in pinkeye and/or wound treatment. Many of these treatments may be used under veterinary supervision. While others can be practically applied without a veterinarian's help.

<u>Evaluation Question #4:</u> What does the National List currently allow for pink eye and wound treatment?

One of the most compelling aspects of organic farming is system health. Organic health management includes the creation of a complete system for sustainable livestock welfare minimizing vectors of disease and ensuring livestock are provided proper nutrition and environment to build a strong natural immune repertoire when stress and pathogens occur (Coffey and Baier, 2012). Water washing, and isotonic saline washing are allowed for organic livestock production. Non-synthetic (natural) herbal microbiocide decoctions are not specifically listed in the National List, but are allowed in Organic Livestock production. Ethanol and isopropanol are permitted as topical disinfectants (7 CFR 205.603(a)(1)(i)) and can be used for wound care. Chlorhexidine is also indicated and allowed for surgical procedures conducted by a veterinarian (7 CFR 205.603(a)(6)). Biologics—Vaccines (7 CFR 205.603(a)(4)) for pinkeye are allowed for organic livestock production. For wound care, both hydrogen peroxide hydrogen peroxide (7 CFR

Table 3 Natural substances used for pinkeye and wound treatment		
Plant or substance	Classification Nomenclature	Application
Seabuckthorn	*Hippophae rhamnoides*	Wounds [3]
Parasitic wasps	*Spolangia cameroni*	Pinkeye [3]
Kiwi fruit	*Actinidia deliciosa*	Wounds [8]
Aloe	*Aloe vera*	Pinkeye, wounds [1,4,5]
Calendula	*Calendula officinalis*	Pinkeye [1]
Chamomile	*Chamoemelum nobile*	Pinkeye [1]
Chicory	*Cichorium intybus*	Pinkeye [1]
St. John's Wort	*Hypericum perforatum*	Pinkeye [1]
Olive	*Olea europaea*	Pinkeye [1]
White poplar	*Populus alba L.*	Pinkeye [1]
Rose	*Rosa agrestis*	Pinkeye [1]
Elder	*Sambucus nigra L. ssp. nigra*	Pinkeye [1]
Navelwort	*Umbilicus rupestris*	Pinkeye [1]
Mullein	*Verbascum sinuatum L.*	Pinkeye [1]
Veronica	*Veronica* spp.	Pinkeye [1]
Physic nut	*Jatropha curcas*	Wounds [6]
Bacterial predators	*Bdellovibrio bacteriovorus*	Pinkeye [2]
Brown kelp alginates	*Ascophyllum nodosum*	Wounds [5]
Honey	---	Wounds [5]
Sugar	---	Wounds [5]
Pineapple Fruit Enzymes (bromelain)	*Ananas comosus*	Wounds [7]
Omentum	---	Wounds [5]
Chitosan	---	Wounds [5]
Platelet Gel	---	Wounds [5]
Pink Trumpet Tree	*Tabebuia avellanedae*	Wounds [9]
Brazialian Pepper Tree	*Schinus terebinthifolius*	Wounds [9]
Siam Weed	*Chromolaena odorata*	Wounds [10]

[1]Calvo and Cavero, 2016; [2]Boileau et al., 2011; [3]Skovgard, 2004; [4]Swaim and Lee, 1987; [5]Krahwinkel, D.J. and Boothe; [6]Thomas et al., 2008; [7]Rosenberg et al., 2004; [8]Hafzei et al., 2010; [9]Lipinski et al., 2012; [10]Vijayaraghavan et al., 2017.

205.603(a)(11)) and iodine (7 CFR 205.603(a)(14)) are allowed. In addition, vitamins (7 CFR 205.603(d)(2)) and mineral supplements (7 CFR 205.603(d)(3)), e.g. vitamin A, D, and E, may be added the diet to improve the immune response and the immune health of the eye. The producer of an organic livestock operation must not withhold medical treatment from a sick animal in an effort to preserve its organic status. All appropriate medications must be used to restore an animal to health when methods acceptable to organic production fail. Livestock treated with a prohibited substance must be clearly identified and shall not be sold, labeled, or represented as organically produced (7 CFR 205.238(c)(7)).

References

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