Disinfecting poultry production premises

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Summary: Hygiene and sanitation play a major role in any effective disease control programme for poultry production premises.

One of the important requirements to facilitate hygiene and sanitation is adoption of the 'all-in/all-out' method (i.e. all the birds within a single establishment should be of the same age group), together with the restriction of each enterprise to a single type or species of bird.

Poultry premises and buildings should comply with requirements for isolation from the environment and strict observance of principles of hygiene and disease prevention (e.g. restrictions on movement of staff, equipment and vehicles). A poultry site must be prepared methodically for the entry of each new batch (removal of birds, litter and manure; vector and rodent control; dry and wet cleaning; disinfection; fumigation). Attention should be paid to the terminal sanitation of houses and equipment after depopulation (physical and chemical cleaning, pressure washing, disinfection, fumigation). Particular care should be exercised in the performance of sanitary procedures after a disease outbreak.

Immediate disposal of dead and diseased birds is an important and effective tool in preventing the dissemination of any disease. Disposal methods include the use of burial pits, tanks, burial in trenches, burning, rendering and composting. Regular visual inspection, together with routine testing by microbiological monitoring methods, is very effective in checking the efficacy of cleaning and disinfection.

KEYWORDS: Carcass disposal - Cleaning - Disinfection - Management - Monitoring - Poultry premises - Sanitation.

INTRODUCTION

No amount of drugs, antibiotics or vaccines will permanently solve disease problems on a farm, or in a hatchery, if sanitation is a secondary consideration.

No poultry producer would consider a disease prevention programme to be complete without a comprehensive plan for cleaning and disinfection, which would be inadequate without a rigid set of principles, and good husbandry and management practices.

One of the important requirements to facilitate hygiene and sanitation is adoption of the ‘all-in/all-out’ method (i.e. all the birds within a single establishment should be of the same age group), together with the restriction of each enterprise to a single type or species of bird (11).

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Poultry premises and buildings should comply with requirements for isolation from the environment and strictly observe principles of hygiene and disease prevention (18).

The measures required for effective cleaning and disinfection, as well as prevention of recontamination on poultry premises, are described below (8, 17).

SANITARY CONDITIONS OF PRODUCTION UNITS

A poultry production unit should be established or constructed at a safe distance from other premises containing live or slaughtered poultry or offal, and away from any road connecting other poultry premises.

The poultry houses should be constructed with materials which can be easily cleaned and disinfected (avoid the use of wood).

Openings in the walls of poultry houses should be covered with wire netting, and the buildings should be kept closed and locked to prevent the entry of humans, animals, birds and rodents.

An area of land 2 m in width around a poultry house must be free of objects and vegetation (a hard surface must be used for at least 1 m of this width).

Entry to the poultry premises must be through rooms in which showers can be taken and clothes changed.

In each poultry house, the floor, ceiling, walls, windows and doors must be entire and solid, as well as easy to clean and disinfect.

The silo and unloading devices should be located and designed for ease of cleaning and disinfection.

The drinking water system should be constructed in a way which facilitates flushing through for thorough cleaning and disinfection.

Waste water from the poultry premises should be removed using a system which eliminates the risk of spreading disease.

All implements, equipment and machinery used within the production unit should be made from materials which are easy to clean and disinfect.

GENERAL REQUIREMENTS

The aim of sanitation and disinfection is to reduce or kill microbial populations which present a threat to the health of flocks (23).

Cleaning and disinfection involve the physical and chemical removal (usually using detergent and water) of contaminating debris, and the reduction or elimination of pathogenic organisms in or on materials, so that these no longer present a health hazard (5).

The cleaning and disinfection process requires extremely careful planning.

Poultry production units should always be completely cleaned and disinfected after the departure of each flock from the premises, and before the arrival of the next batch. Cleaning and disinfection should be performed simultaneously in all buildings on the premises.
The presence of organic material reduces the efficacy of any disinfectant and renders some disinfectants inactive.

Cleaning and vector-control procedures should commence immediately after the removal of birds from the buildings.

A poultry production site must be prepared methodically for each new batch of birds.

**Preparations prior to cleaning**

All birds should be removed from the buildings before cleaning commences.

Vector control procedures should be applied immediately after the birds have been removed. Ectoparasitic vectors include flies, mites, ticks, lice, fleas, bugs, beetles and cockroaches (27).

To minimise the number of insects (e.g. beetles) in conventional open buildings, a clean zone should be established – 1 m wide from the inside wall, along the entire length of the house – by bringing the litter from the edge to the centre of the building. An approved insecticide should be applied to the ‘clean zone’ thus produced. If possible, the house should be closed and sealed, and an approved insecticide sprayed both inside and outside the building (including a 6 m wide area around the house). The building should be left closed for three to four days.

It is important to perform the vector control procedure while the building is still warm, as insects will tend to hide and hibernate as the building cools, thus making eradication more difficult.

A variety of chemical compounds is available for vector control (e.g. lindane, carbamates, pybuthrin, malathion and 12% fenochlorphos). These are available in forms to be used for the treatment of individual animals, as aerosols, or for mixing in the litter at a rate of 1 kg per 60 m$^2$. Piperoxylbutoxide/pyrethrums may be employed in a low-pressure aerosol dispenser or from high-pressure aerosols; malathion may be sprinkled on the litter at a rate of 1 kg per 10 m$^2$. Chemical compounds are also available in the form of liquids for painting on perches in poultry houses.

Rodent control should be performed immediately after house depopulation, using baits containing rodenticide.

All feed should be removed from feeders so that rodents will be quickly attracted to the baits. Baits should be placed inside and outside the buildings, in accordance with the directions supplied by the manufacturer.

Rodenticides which cause the death of rodents after a single meal (e.g. brodifacoum or bromadiolone) should be preferred. All dead rodents should be collected, removed and destroyed.

Baits should be handled with caution, as they are also poisonous to non-pest rodents, chickens, animals and humans.

The litter and manure from floors or cages must be removed and disposed of or treated in a manner which precludes the possible spread of any infection. Litter may be burnt, buried (this method is generally preferable and is advisable after a disease outbreak) or stacked into heaps for composting over at least three days. The temperature within a compost heap should reach 60°C (facilitated by moistening the litter), at which stage the heaps should be rearranged so that the external layers are in
the centre, and the temperature must then return to 60°C. This operation should be performed at a distance from the farm premises, and the compost heaps covered with a nylon sheet to prevent dispersion of litter or manure.

**Dry cleaning**

All removable equipment and fittings should be dismantled and removed from the building.

Dry cleaning (i.e. brushing, scraping, etc.) should be performed inside and outside the buildings, including storage and entry rooms, egg rooms, egg coolers, hallways and stairways.

Fans and other air inlets should be cleaned from the outside.

Inside the building, dust and other dirt on ceilings, light fixtures, beams, ledges, walls, cages, fan parts, air inlets, floors (especially in corners), pit ends and walkways should be brushed, swept, vacuumed, scraped and wiped. Commercial vacuum cleaners, air blowers, wire brushes and low-speed mechanical scrapers may be useful. Manual scraping, hand sweeping and shovelling will be necessary around the perimeter, doorways, walkways, support poles and corners of most houses to ensure satisfactory cleaning. All operations should begin with the uppermost surfaces and proceed downwards to minimise possible contamination of previously cleaned areas.

Egg conveyance equipment should be opened and egg belts removed. All egg debris, dust and dirt should be swept away.

Power supplies to electrical equipment should be switched off.

Electrical equipment which cannot be removed (e.g. motors, switches) should be dry cleaned with compressed air or by brushing.

All material which cannot be properly cleaned (e.g. surfaces made of ‘rough’ wood), as well as deteriorated equipment, should be removed and replaced with new equipment.

Every part of the poultry house and associated equipment must be repaired (floor cracks filled, door frames repaired, damaged panels replaced, etc.) and made mouse- and bird-proof. Waste materials from repair work should be collected frequently and disposed of, or preferably, burnt.

All the premises outside the poultry houses must be thoroughly cleared of all debris, dirt and feathers; waste materials should be burnt. A 2 m zone around the house should be freed of vegetation and waste.

All equipment should be collected in a specific area outside the buildings for further cleaning.

Used clothes (overalls, rubber boots, gloves, etc.) should be washed at 65°C.

**Wet cleaning**

Wet cleaning involves soaking, washing and rinsing. Detergents and other surfactants of alkaline pH (8.5-10) are often added to washing solutions to loosen debris and films, and improve the penetration of cleaning agents.

A high-pressure washer should then be used, preferably with warm (60°C) water. Adjustable pressure of 80-150 bar (1 bar = 10⁵ Pa) is desirable. Sprayer attachments and
nozzles with different angles and working capacities should be available to facilitate the washing of ‘hard to reach’ areas.

Air inlets and fan drums should then be cleaned by high-pressure washing from above and/or outside the house.

Ceilings, walls, walkways, steps and cross-over platforms, egg rollers, all egg conveyors, cross belts, floors under conveyors, stairs to pits (used for equipment [e.g. egg collectors] or manure, etc.), outside stairs and concrete pit floors must all be washed using high pressure until they are completely clean.

Special attention should be paid to the undersides of troughs, and to obvious and hidden surfaces of all chains. Extreme care should be exercised in cleaning the egg elevator.

Other rooms and spaces should be carefully washed at high pressure (storage and egg room, egg coolers, hallways and personal facilities [break-, wash/shower- and rest-rooms]).

All the wet cleaning is performed systematically, from the back to the front of the building, and from the top downwards, moving carefully from one short side of the house towards the other. If much water or dirt is collected on the floor, the cleaning should be stopped and this water or dirt removed to avoid recontamination.

The equipment collected outside the buildings is washed manually or using high-pressure water, following the same procedure as for the interior of the building. Some of the equipment may require soaking to loosen soilage, and a special pit or bath for this purpose would be extremely useful.

When cleaned, the equipment must not be placed on the floor, but arranged so that it may be placed and temporarily fixed (with sufficient drying space) above floor level.

Water pipes should be flushed with water at the highest pressure available. A water detergent is then used in accordance with the recommendations of the manufacturer.

The pressure tank is filled with water detergent, and all parts of the tubes are filled. The detergent should remain in the tubes for 24 h. The tubes are then flushed through with water until the water is clear.

Water pipes which can be dismantled (thin water tubes from the ceiling to the drinkers) are flushed individually with high-pressure water, filled with water detergent and placed in a commercial detergent solution in a plastic or non-corrosive container.

Electrical equipment (e.g. switches, fans) should be waterproof to allow for high-pressure washing. Extreme care should be taken to prevent spray from entering electric motors. Duct tape can be used to cover the slots in motor housings prior to wet cleaning. This tape should be removed after wet cleaning is completed.

Silos must be completely emptied and cleaned from above by high-pressure washing, both inside and outside. Feed taken from a silo must not be used for subsequent batches of poultry.

A final rinse in water of drinking quality is suggested to obtain a truly clean building.
DISINFECTION

When all rooms, spaces and equipment are clean, and the equipment is drying in the cleaning area, disinfection should be commenced within 24 h.

No single disinfectant is best for all purposes; to choose the right disinfectant, one must consider the characteristics of the wide variety of products available.

All disinfectants – whether sprays, foams, aerosols or fumigants – work best at temperatures above 68°F (20°C).

The temperature for chlorine- and iodine-based disinfectants should not exceed 110°F (43°C). When these products are used, the house should be soaked with water again, prior to disinfection, and the relative humidity of the air should be high (65-80%).

The use of pressurised sprays (500-1,000 psi [35-70 × 10^5 Pa]) is advisable to help force disinfectants into wood pores, cracks and crevices. Disinfection is performed in the same order as wet cleaning, i.e. by moving from the back to the front of the house, and from top to bottom.

One U.S. gallon (3.8 l) of diluted disinfectant is ordinarily applied to approximately 100-150 sq. ft (10-15 m^2) of surface area. Cage surface is included in this calculation by adding 30% to the total calculated area (floor, ceiling and walls) for disinfection. Usually, sufficient disinfectant is sprayed on every surface so that the small drops reach the lower parts of the walls and the concrete floor is wet.

For the disinfection of buildings, it is advisable to use formalin 4% end solution (commercial formalin 37.5% solution diluted 1:8 in water) with propylene glucol. The propylene glucol is essential to enable the formaldehyde to penetrate pores, cracks and spaces between metal plates where joints are riveted or welded together.

The best procedure is to disinfect equipment in special premises and then return it to the rearing area when disinfection is complete.

Small equipment, and equipment which can be dismantled, may be placed in a special plastic or stainless steel bath or container (containing a solution of iodic, phenolic or quaternary ammonium compounds) for no more than 2 min. In tropical countries, poultry house equipment may be placed in the sun after cleaning for further disinfection.

Electrical equipment (waterproofed), egg-handling equipment and other large equipment should be disinfected in accordance with the recommendations provided by the manufacturers of the equipment and the disinfectant. Fuse boxes should be disinfected by hand, using a cloth soaked in disinfectant. All fuses should be removed before disinfection.

All accessory decontamination equipment (e.g. rakes, shovels, scrapers, brushes, trucks, tractors, manure spreaders and bucket loaders) should be cleaned and disinfected after use and stored in a secure location.

The water system should be decontaminated using commercial disinfectants, carefully following the recommendations. Dismantled tubes should be filled individually with a water disinfectant and soaked for 24 h.

Water pipes which cannot be dismantled should be filled with commercial disinfectant through the pressure tank, left for 24 h, and then flushed through with fresh water, using the highest pressure available.
Disinfection of silos should be generous, using 6% formaldehyde with propylene glycol.

Disinfection of dirt floors is virtually impossible. In situations where dirt floors cannot be concreted, fumigation can be performed (under a nylon or polythene cover sheet) using methyl bromide at a rate of 100 g per m\(^2\) for 24 h. Alternatively, disinfectant could be applied to the floor at a rate of 4 l per 10 m\(^2\).

Formaldehyde gas used on dirt floors is effective only on the surface, as fumigation is unable to affect pathogens at a depth of more than 2 cm (19, 20).

The efficacy of a disinfectant depends on the duration of contact with the soiled environment. Most disinfectants are dissolved in water and contact lasts until the applied disinfectant solution is dry.

The contact time of disinfectants has been increased severalfold with the advent of foaming techniques. Foam takes a lot longer to dry and, consequently, the antimicrobial activity of the disinfectant is greatly increased (12).

Ultra-violet (UV) radiation is not an effective method of destroying microorganisms in poultry production environments. UV light can disinfect by damaging the nucleic acid of pathogens, but this is only effective when the source of light is positioned close to the surface to be treated; the surface must be free of dust and exposed to direct rays (12).

The question is often asked: how long should a house be left unoccupied between batches? The answer should be that, once the full cleaning and disinfection procedures have been followed, there is no merit in the building staying empty.

However, experience shows that security is increased if the time between completion of cleaning/disinfection and the introduction of new birds is not less than 14 days.

Before entering a disinfected area or touching disinfected equipment, all personnel must change into clean clothes and clean, disinfected rubber boots, and must wash and disinfect their hands. Clean overalls must hang on the ‘disinfected’ side of the barrier, and personnel must wear these whenever crossing to this side of the barrier. Used overalls must be removed and placed on the ‘dirty’ side for washing. Boots or shoes used on the ‘dirty’ side must be removed, and new rubber boots put on, when passing the barrier into the ‘disinfected’ area. Before entering the ‘disinfected’ zone, personnel must stand in a boot disinfectant bath for 20 sec, during which time they may wash and disinfect their hands. Only when these procedures have been completed can personnel enter the premises and take part in the work.

**General guidelines for disinfectant use**

The instructions of the manufacturer should always be followed when using any disinfectants. This ensures economy, efficacy, and human and flock safety.

Careful attention to mixing is important. Each disinfectant is the result of careful formulation; any addition of detergents, surfactants or insecticides to a disinfectant without the approval of the manufacturer could dangerously reduce the efficacy of one or more of the products contained in the mixture.

Like all farm chemicals, disinfectants are often poisonous and invariably highly concentrated. They should be stored in closed containers, away from feed, feed additives and medication, and out of the reach of children. When spraying or fumigating, appropriate protective clothing should be worn.
The importance of cleaning prior to disinfection cannot be over-emphasised. The ability of disinfectants to function in the presence of organic matter varies. Some disinfectants may be inactivated by extremes of pH or by soap residues.

Hot disinfectant solutions penetrate and disinfect better than cold solutions. This is especially important in areas where there are many cracks and crevices.

Care should be taken to ensure that the disinfectant is not corrosive to the surface to which it is to be applied.

If a disinfectant is used as a drinking water sanitiser, the disinfectant must be removed prior to the administration of a live vaccine in the water. Like any poultry health product, disinfectants are only effective if used correctly. Proper use of disinfectants can greatly improve sanitation at a reasonable cost, while improper use is a certain waste of time and money.

**Formaldehyde and formalin are dangerous chemicals which present serious health and safety hazards.** Formaldehyde fumigation may soon be unlawful in some countries (e.g. Israel and the United States of America). The provision of gas masks, protective clothing and rescue plans is essential.

**Procedure following a disease outbreak**

Following a disease outbreak, the affected building should be closed and isolated from all visitors. Bedding, litter and all areas in intimate contact with the stock should be sprayed with a strong disinfectant (e.g. formalin or phenolic).

The litter should then be removed from the building and may be burnt or buried to prevent subsequent contact with livestock.

Portable equipment and fittings should be treated as described above, preferably within the building; these should then be taken outside and aerated.

The house should be treated as suggested above. Where an earth floor is present, it is wise to remove the top 10-15 cm and to disinfect or fumigate with methyl bromide or sodium hydroxide (NaOH).

The areas immediately outside entrances to the building should be treated with disinfectant, and footbaths should be provided.

Hygiene and disinfection must be placed high on the list of priorities for control of infection following a disease outbreak (7).

The factors affecting the efficacy of disinfection are detailed below.

**Choice of disinfectant**

Whenever possible, the product chosen should have been proved to be effective against the relevant disease organisms in an independent test, preferably conducted by a governmental or similar institution.

**Dilution rate**

If product selection has been possible on the basis of independent test data, data must also be sought on the dilution rate which proved to be effective against the known pathogen.

**Application rate**

To achieve effective disinfection, surfaces must be thoroughly wet; this requires a minimum application rate of 400 ml/m².
**Detergency**

To gain access to microorganisms, a disinfectant must be able to penetrate organic matter. This requires a high level of detergency.

**Contact time**

Each disinfectant requires a minimum contact time to be effective against a particular disease organism. In practice, at least 30 min should be allowed.

**Temperature**

Disinfectant activity decreases with temperature, although some products are affected to a lesser extent. A disinfectant should be selected which has been proved to be effective at low temperatures (e.g. 4°C).

**Organic challenge**

The effect of the presence of organic matter on the efficacy of disinfectants varies. Products which have proved effective in the presence of high levels of organic material should be considered in the selection of a disinfectant.

**Water quality**

All disinfectants are inactivated to some extent by hard water. In selection, one should consider proven activity when diluted in hard water.

**Carcass disposal**

Bird carcasses must be collected daily and disposed of immediately. Poultry carcasses must be disposed of by methods which prevent dissemination of any disease – regardless of whether death was due to a serious clinical infection or routine mortality – while also protecting the environment from pollution and maintaining a good public health image (25).

The disposal methods currently available are described below.

**Burial in pits**

Burial pits are commonly used because they are convenient, inexpensive and simple; they require little labour and supervision, and cause minimal problems if properly located and constructed. Pits should be constructed on well-drained sites with a compact subsoil. If soil structure is highly permeable, lining the pit with 20 cm of clay or a plastic sheet should minimise the danger of polluting ground water. Walls should be shored up or boxed in (preferably with cross-tie posts and lumber), with the support structure extending below the upper level of compact subsoil to prevent the sides from caving in.

Pit covers must fit tightly. These may be made from a variety of materials including cross-ties, heavy sheet or tank steel, or reinforced concrete. The cover should extend 30-60 cm beyond the pit walls to maintain support and minimise seepage and cave-ins. Soil should be mounded over the cover to a depth of at least 30 cm and for approximately 1 m on all sides to ensure that the cover is air-tight, to prevent animals from burrowing into the pit, and to minimise water seepage.

To utilise pit capacity fully, openings at least 20 cm in diameter for chickens (30 cm for turkeys) are required for every 1.5-2.0 m of cover length. Lids on the cover openings must fit tightly to keep out insects.
Pits are easily dug with a backhoe (excavating machine). Size requirements vary, depending on flock or farm capacity and expected mortality. A properly constructed disposal pit 5 m long, 2 m wide and 3 m deep (30 m³) should be sufficient to handle carcasses from a 100,000-layer farm for two years, assuming mortality of 6-8% per year. For small operations, a pit of 12 m³ (2 x 2 x 3 m) can serve a total population of 15,000 birds.

A deeper pit will ensure more rapid decomposition. Studies show that heating pits can increase decomposition in cold weather. Some producers prefer pits to be dug using rotary equipment. Such pits are normally 75 cm in diameter and 10-12 m deep. Deep pits can endanger ground water supplies and should not be utilised where a shallow water table exists.

When pits are full, permanent type covers should be removed and dirt mounded and packed to a depth of at least 1 m over the pit to compensate for settling and prevent rainwater seepage.

A few words of caution should be issued here: improper construction or location can create major problems. Access of insects and predatory animals, cave-ins, seepage, collection of water and escape of odours must be prevented. Proper location in a well-drained area minimises seepage into the pit and protects ground water supplies and farm appearance. Pits should not be dug near poultry houses or within 50 m of water wells, surface water or residences. In recent years, the burying of carcasses has been questioned by producers, local and regional authorities and the public, all of whom are concerned about the impact of burial on water quality. Many locations are unsuitable for the installation of burial pits. Soil type and ground water level are two major factors which limit the use of this method of disposal. When choosing the site for a burial pit, care should be taken to ensure that drinking water supplies will not be contaminated, that the roof or walls will not cave in, that animals will not dig into the pit, that flies and other insects cannot gain access and, above all, that children cannot fall in.

**Tank disposal**

The use of an electrically-heated septic tank is a safe but expensive method for the disposal of carcasses and waste products. The method consists of digesting carcasses and/or waste products in a heated septic tank. Heat is applied at 37.8°C, and electricity is required at a rate of 2-3 kWh/day to maintain this temperature over the two weeks necessary for destruction of all but the bones of carcasses. This system depends on the activity of mesophilic bacteria accelerating decomposition; these bacteria multiply best at 32.2-37.8°C. Neutralising the mass at intervals with lime and adding hot water further accelerate decomposition.

**Burial in trenches**

Burial of carcasses in trenches is time-consuming and may complicate land use. Daily trench burial requires labour and supervision, and can be interrupted by weather. Unsanitary situations may arise if carcasses are not covered each day by several metres of firmly-packed soil to prevent recovery of carcasses by predators. This method is mostly used in emergencies, for losses which create a serious disposal problem.

**Burning**

Burning is the most reliable means of destroying infectious material. Many practical smokeless and odourless incinerators are commercially available for the disposal of animal carcasses. Incinerators should be placed downwind of both poultry houses and human habitation. Carcasses must be reduced to a completely burnt white ash.
However, appropriate incinerators are expensive to construct and – together with high fuel costs, increasingly frequent complaints from neighbours and stronger pollution regulations – this is forcing producers to consider other methods of carcass disposal.

**Rendering**

Rendering can be used to convert poultry carcasses into a valuable, biologically-safe protein by-product meal. The possible spread of pathogenic microorganisms during routine collection and transportation of poultry carcasses to a rendering facility is viewed as a potential threat. However, removing poultry carcasses from the farm is ideal from an environmental point of view, and rendering produces a valuable feed ingredient.

One of the major concerns with a centrally-located carcass disposal site is disease transmission. Reliable biosecurity of the disposal sites is essential to prevent disease transmission.

The rendering temperature should be sufficient for sterilisation, and the bed of the truck used to transport the carcasses should be washed and disinfected. Containers used to haul the carcasses should be steam cleaned and sterilised.

Transportation costs have made this method expensive (i.e. approximately US$0.30/kg) in comparison to other alternatives, such as burial or composting (less than US$0.02/kg and US$0.06/kg, respectively). Freezing carcasses for short-term storage prior to transportation to a rendering facility is effective. However, this method has also proved to be expensive. Large-capacity units are usually required, as daily disposal requirements may exceed 100 kg of carcasses at near body temperature (41°C).

Electrical costs for the operation of high-capacity refrigeration equipment have been estimated at approximately US$0.10-0.20/kg for carcasses stored and collected at weekly intervals.

It should also be remembered that commercial or contract haulers of dead carcasses may introduce another disease from a separate outbreak unless strict precautionary measures are taken (2).

**Fermentation**

A controlled natural process has been successfully used as a method for preserving food and feedstuffs for millennia, and has been well documented as a scientifically sound method for the preservation of organic materials. Initial studies described methods for preserving poultry carcasses by lactic acid fermentation. Successful fermentation occurs due to the combination of prescribed amounts of carcass material with a fermentable carbohydrate source, such as sugar, whey, molasses or ground corn. For effective fermentation to occur, carcasses must be ground into particles of ≤ 2 cm in length; this facilitates acidification of tissues. Grinding aids the dispersal and mixing of anaerobic lactic acid-forming bacteria present in the intestine. Bacteria which produce lactic acid ferment the carbohydrate source, resulting in the production of volatile fatty acids and a subsequent decline in pH to below 4.5, which preserves the nutrients in the carcasses.

Pathogenic microorganisms associated with the carcasses are effectively inactivated or inhibited during the fermentation process due to the decrease in pH. Fermented material can be stored and will remain in a stable state for several months. Fermentation could therefore be initiated on-farm until carcass amounts are sufficient...
to warrant the cost of transportation for rendering. Fermentation facilities include one or more specifically-designed and -built grinding units, enabling the simultaneous addition of a carbohydrate source during the grinding of carcasses. Broiler carcasses are ground daily and milled corn is added at a ratio of 1:5. The resulting mixture is directly fed into a 1,000 l enclosed tank.

Weekly pH measurements are obtained from the fermentation tank(s) at approximately 30 cm below the surface. Typically, the pH value of the fermented product falls below 5.0 within ten days. All resulting ferment is transported for rendering at the end of a typical 'grow-out' cycle (45-49 days later). Fermentation can be adapted for the stabilised, pathogen-free storage of broiler carcasses during a typical seven-week grow-out. Unlike routine collection of fresh carcasses, fermentation and subsequent storage of dead poultry reduces transportation costs by 90% and eliminates the potential for transmission of pathogenic microorganisms via rendered products (2).

**Composting**

Composting is a controlled, natural process in which beneficial microorganisms (bacteria and fungi) reduce and transform organic waste into a useful end-product (termed 'compost'). Initial work has indicated that composting poultry carcasses provides an economical and biologically safe means of converting daily mortality into an odourless, humus-like material which is useful as a soil amendment and a source of plant nutrients (15).

On-farm composting of poultry carcasses requires two types of composting bins: primary and secondary.

Daily mortality is sequentially layered into the primary bin with used or caked litter, straw and water. The proportion (by weight) of the various materials required for composting poultry carcasses is as follows:

- carcasses 1 part
- manure 2-3 parts
- straw 0.1 part
- water 0.25 part.

A 30 cm layer of caked or used poultry litter containing pine shavings, sawdust, peanut hulls or rice hulls is first placed on the concrete floor of the bin. A layer of straw is added to aid aeration and supply an adequate source of carbon.

A single layer of carcasses is then placed into the bin and water is added to maintain a moist, but not saturated condition. Finally, the layer of carcasses is covered with manure for subsequent layering. As mortality proceeds, successive layers of straw, carcasses, water and litter are placed in the primary bin. When the bin is almost full, a final layer of manure is placed over the carcasses (1).

A simple poultry composter may be constructed using a concrete slab as a base, and may be layered with the following materials (from the top downwards):

- double layer of manure (top layer; left dry)
- carcasses
- straw
- manure
- carcasses
- straw
- manure
- carcasses
- straw
- double layer of manure
- concrete slab (as base).

During the composting process, the volume of material will reduce by 25-30%. This will enable the operator to add more material to top off the bin.

Ideally, the size of the composter will be such that the average daily mortality will equal one layer of carcasses in the primary bin. Each subsequent day, the carcasses and the other elements should be layered (manure, carcasses, straw, manure, carcasses, straw, etc.) in the bin.

Up to half of the manure and half of the straw used in primary composting may be substituted with recycled compost. Recycled compost produces a rapid commencement of composting in primary boxes, and increased recycling produces a more stable end product. Recycling also reduces material costs.

An ideal composter should have an impervious, weight-bearing foundation (concrete) to prevent contamination of adjacent areas and secure the contents of the composter from dogs, rodents and other scavengers. Pressure-treated building materials which resist biological composting activity should also be used, and a roof should be fitted which keeps out rainwater and ensures all-year-round operation.

Composter size is based on broiler farm capacity, overall bird size at the end of the production cycle and mortality rate. Studies show that the composter should be designed using the following formula:

$$\text{Capacity (m}^3\text{) Maximum Average market}$$
$$\text{of primary} = \text{no. of birds} \times \text{weight (kg)} \times 0.00015.$$  
$$\text{composting bin on farm of bird}$$

For a 20,000-head capacity farm with final bird weight of 2 kg, a primary composting bin of 6 m$^3$ is required. Field studies have shown that at least 1 m$^3$ of secondary composting bin is necessary for each m$^3$ of primary bin capacity. The temperature of the compost mixture increases rapidly as bacterial action progresses, rising above 55°C within five to ten days. The temperature should be monitored with a probe-type thermometer. The increase in temperature has two important effects:

- hastens decomposition
- kills pathogenic microorganisms, weed seeds and fly larvae.

Temperature begins to decrease in the primary bin after a further 14-21 days. At this point, material is moved from the primary bin to a secondary bin, aerated in the process and allowed to proceed through a second temperature rise. After the second heating cycle, composted material can be safely stored until needed for land application.

For composting to be a viable method for the disposal of poultry carcasses, it is paramount that the composting process completely inactivates pathogenic (avian and human) microorganisms prior to land application. Studies indicate that two-stage composting effectively inactivates poultry-associated bacterial pathogens. Aeration of the compost - simply by turning the pile from the primary bin into the secondary bin to
produce a second heating cycle – ensures effective inactivation of these microorganisms.

When properly managed, composting is a biosecure, relatively inexpensive and environmentally-sound method for the disposal of poultry carcasses. Composting is becoming more widely used as an alternative method for the disposal of poultry carcasses (1, 22).

**MONITORING THE EFFICACY OF CLEANING AND DISINFECTION**

An official control veterinarian should be appointed for the inspection and monitoring of all hygienic operations on poultry production premises.

The control veterinarian should be kept informed of all events within the branch of production being inspected.

The owner of the birds should be advised on questions related to hygiene and other measures to prevent infection of the farm and a possible disease outbreak.

The inspector should ensure that all stages of the operation are performed properly, and careful visual inspection should be performed immediately after each step of cleaning and disinfection.

Inspection should also ensure that all necessary repair work has been completed before commencing the final cleaning phase.

Visual inspection (for cleanliness) of every part of the premises is best performed in good light, when the house and equipment have dried.

While visual cleanliness is a systematic prerequisite, bacteriological samples are also necessary to determine the efficacy of cleaning and disinfection. Bacteriological samples should be taken periodically (at least twice per year from empty farms with no disease history) and after any disease outbreak.

The best time to take a sample is two to three days after disinfection.

Assessments of the sanitation status of poultry production units after disinfection involve determining the number of viable microorganisms present (4).

A direct streaking technique, which can be used to obtain a guide to the number of bacteria present, is described below.

The cotton wool-tipped swab is drawn twice along the surface and streaked directly onto one quarter of an agar plate. This swabbing is performed in four areas for each surface and the swabs are streaked onto the four quarters of a single plate. The plates are then incubated at the appropriate temperature and a simple comparison determines the hygienic standard (13, 16).

If knowledge of the source of contamination is required, it may be necessary to sample a larger number of sites, employing a direct streaking technique over larger areas and using a single agar plate per item. This is performed using a cotton wool-tipped swab, sampling a known area bound by a square template (or a known distance, using a measure as a guide) and then directly streaking the swab onto a whole plate of the appropriate medium. After incubation at a suitable temperature, the growth on the plate is assessed. The source of the contamination is usually obvious after examining the
plate. By this method, approximately 100 plates may be inoculated in an hour (with an additional 30-45 min required in the laboratory) (14).

On many occasions when it is necessary to determine the number of microorganisms present, the nature of the surfaces causes conventional cotton wool-tipped swabs to disintegrate. To overcome this, 4 x 3 cm cellulose sponges or quartered absorbent washing-cloths can be used. Both can be sterilised at 121°C for 15 min, then wrapped in greaseproof paper secured by autoclave tape. Quarter-strength Ringer’s solution (20 ml) is placed in a suitable wide-necked jar and the sponge or cloth is taken from its wrappings (a sterile polythene glove should be worn), dipped in the diluent and used to swab a defined area. The sponge is then replaced in the jar and transported to the laboratory for a conventional plate count.

The Petrifilm aerobic count plate is a reliable, ready-made medium system for enumerating total aerobic bacteria populations (6, 9, 10, 21). Petrifilm aerobic count plates contain ‘standard methods’ nutrients, a gelling agent soluble in cold water, and a tetrazolium indicator dye which facilitates colony enumeration.

Directions for use are as follows:

- Place the Petrifilm aerobic count plate on a flat surface.
- Lift the top film. Hold a pipette perpendicular to the plate and carefully dispense 1 ml of the sample onto the centre of the bottom film.
- Release the top film down onto the sample.
- Distribute the sample evenly, using gentle downward pressure on the centre of the plastic spreader (recessed side down). Do not slide the spreader across the film. Remove the spreader and leave the plate undisturbed for 1 min to permit solidification of the gel.
- Incubate the plates in a horizontal position, with the clear side uppermost, in stacks not exceeding twenty plates. Follow current total plate count standards to determine the incubation temperature. Temperatures above 37°C are not recommended. Incubate plates for 48 ± 3 h.
- Count bacteria using a standard colony counter. The reduction of the tetrazolium indicator dye will cause the colonies to become red. All dots should be counted as colonies, regardless of size or intensity.

The bacterial contamination of horizontal surfaces (e.g. tables and building ledges) and vertical surfaces (e.g. walls and doors) can be examined by pressing solid agar onto the surfaces. For this purpose, Rodac plates or elongated rolls of nutrient agar (‘agar sausages’) may be used. Both the plates and rolls of agar are very useful when the distance between the hatchery and the laboratory is relatively short. In addition, the agar technique gives a direct bacterial count per standard surface area (3, 24).

In the case of a bacterial infection on the farm, microflora may also be identified by these methods, if required. When the dilutions have been prepared for a total viable count, the diluent and sponge are bulked in suitable groups and the bulked samples are examined for pathogens as required. In the experience of the authors, the drag swab method provides a good assessment of presence of infection after an outbreak of salmonellosis contamination, as follows (26):

- Prepare two 10 x 10 cm gauze sponges.
- Attach a 2 m length of string to each gauze sponge by passing one end of the string through a central hole in the sponge and tying a secure knot.
- Seal the strings and gauze in an autoclave bag and perform standard autoclave procedures.
- Pre-moisten the two sterile sponges with approximately 5 ml of double-strength skimmed milk medium.
- Drag two pre-prepared autoclaved swabs over the entire length of the floor surface, forwards and backwards, for a minimum of 15 min.
- One nest box sample should be collected by using two sterile sponges. Wipe the entire interior surfaces of at least half of the total nest boxes in the house with two gauze sponges (use one sponge for each quarter).
- Wipe at least half of the total surface area of the equipment examined with the sterile sponge. Total swabbing time should be at least 5 min per sample.
- Cut the strings from the gauze and place each sample in a separate sterile bag, adding approximately 5 ml of double-strength milk medium to each.
- All samples should be packed separately (to prevent contamination), labelled, and refrigerated immediately after collection and during transport to the laboratory.

It should be emphasised that, although microbiological methods are an important tool in estimating standards of cleanliness, the use of visual assessment - especially of electric fittings, beams and ledges - should not be neglected.

**CONCLUSION**

Complete sterilisation of a site is impossible under most practical farming conditions, but every possible measure which helps to reduce the challenge is worthwhile. Practical experiences show very clearly that the efficacy of, and the benefit gained from, all procedures is determined by the planning, organisation and accurate performance of the various steps of the sanitation programme.

It is essential that all those involved understand the importance of all cleaning and disinfection procedures, and that everyone has an interest in obtaining successful results.

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**DÉSINFECTION DES ÉTABLISSEMENTS AVICOLES. – M. Meroz et Y. Samberg.**

*Résumé*: L'hygiène et l'assainissement dans les établissements avicoles jouent un rôle majeur dans tout programme efficace de lutte contre les maladies.

L'une des conditions essentielles pour faciliter l'hygiène et les techniques d'assainissement est que tous les oiseaux d'un même établissement appartiennent au même groupe d'âge (méthode all-in/all-out) et que chaque entreprise s'en tienne à un seul type ou à une seule espèce d'oiseau.
Les établissements avicoles devraient être isolés de l'environnement et respecter strictement les principes d'hygiène et de prévention des maladies (limitation des mouvements de personnel, d'équipements et de véhicules). Tout site d'élevage doit être préparé méthodiquement avant chaque nouvel arrivage de volailles (il convient d'enlever les oiseaux présents, la litière et le fumier et de procéder à l'élimination des vecteurs de maladie et des rongeurs, au nettoyage par voie sèche et humide, à la désinfection et à la fumigation). Il faut être très attentif à l'assainissement des installations et des équipements à la suite d'un abattage sanitaire (nettoyage physique et chimique, nettoyage sous pression, désinfection, fumigation). Il convient de prendre des précautions particulières lors des opérations d'assainissement après une épidémie.

Pour éviter qu'une maladie ne se propage, il faut immédiatement se débarrasser des oiseaux morts ou malades. Les méthodes existantes incluent l'enfouissement dans des fosses, des cuves ou des tranchées, l'incinération, le broyage et le compostage. Une observation régulière, associée à des tests de routine basés sur des méthodes de contrôle microbiologique, permet de vérifier l'efficacité du nettoyage et de la désinfection.


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DESINFECCIÓN DE LOS ESTABLECIMIENTOS AVÍCOLAS. – M. Meroz e Y. Samberg.

Resumen: La higiene y el saneamiento en los establecimientos avícolas desempeñan un papel de gran importancia en todo programa de lucha contra las enfermedades.

Una de las condiciones esenciales para facilitar la higiene y el saneamiento es que todas las aves de un mismo establecimiento pertenezcan al mismo grupo de edad (método all-in/all-out), cada empresa limitándose a un solo tipo o una sola especie de ave.

Los establecimientos avícolas deberían aislarse de su entorno y respetar escrupulosamente los principios de higiene y de prevención de enfermedades tales como la limitación de los desplazamientos de personal, de equipos y de vehículos. Los lugares en que se llevará a cabo la cría deben prepararse métódicamente antes de la llegada de cada nuevo grupo de aves: es conveniente quitar las aves presentes, la yaciza y el estiércol, eliminar los vectores y roedores, limpiar en seco y con agua, desinfectar y fumigar. Es necesario prestar mucha atención al saneamiento final de las instalaciones y equipos tras una despoblación: limpieza física, química y bajo presión, desinfección y fumigación. Y conviene asimismo tomar precauciones especiales cuando el saneamiento se lleva a cabo después de un brote de enfermedad.

Para evitar la propagación de enfermedades, es necesario eliminar inmediatamente las aves muertas o enfermas. Los métodos para hacerlo incluyen la sepultura en fosas, tinas o zanjas, la incineración y el procesamiento para uso como abono. La observación regular sumada a la práctica de pruebas de rutina basadas en métodos de monitoreo microbiológico permitirán verificar la eficacia de la limpieza y la desinfección.

REFERENCES


