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Biosecurity and Disinfection Controls of Poultry Microbial Pathogen Infections in Nigeria

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ABSTRACT

In Nigeria, industrial poultry production occupies a place of pride among the livestock enterprises due to its rapid monetary turnover. However, Intensive poultry farming provides the optimum conditions for the concentration of disease causing pathogens and transmission. The presence of these diseases has created the need for the control of poultry pathogens in the intensive farming system. Microbiological contamination can be prevented and controlled using proper management practices and healthcare products such as disinfectants. Disinfection consists of destroying disease-producing microbes by chemical and physical means. Hygiene involves the setting up of physical barriers to restrict the access of disease causing agents to the flock and to limit the spread of infectious materials. Biosecurity on the other hand is the protection of poultry flock from any type of infectious agents, whether viral, bacterial, fungi or parasitic in nature. In many developing countries, such as Nigeria, provision for biosecurity are usually inadequate due to; outdated laws and inadequate legal infrastructure; lack of resources, budget and infrastructure for inspection and enforcement; poor cooperation between agencies; lack of technical resources and infrastructure for risk assessment, etc. Measures to enhance safety of food and good quality poultry products from farm to table are however key concerns for all stakeholders in the industry. Since Global concerns about poultry pathogen play a prime role in poultry exports and food policy decisions in international trade, Nigerian poultry farmers need proper diseases control environment in order to sustain asses to international trade.

Keywords: Disinfection, disinfectants, biosecurity, microbial pathogens, Nigeria

INTRODUCTION

Poultry encompasses a number of domesticated avian species which include the chicken (reared for laying eggs – "layer", or meat production – "broiled") turkey, ducks and other water fowls and game birds. Each species has a uniquely different type of production (EPA, 2007). Poultry production has grown from backyard operations, which provided supplemental income to the family, to a vertically integrated industry. The past two decades has seen a complete transformation in the poultry industry, with a 300% increase in production across the world. This increase is largely due to reliance on intensive farming and transnational production systems. Poultry production is now a global affair (Collins, 2007).

In Nigeria, poultry meat and eggs, offer considerable potential for meeting human needs for dietary animal supply (Folorunsho and Onibi, 2005). In the past however, poultry production was not counted as an important occupation. In some communities, the fowl was used as a means of knowing the time. Nowadays, poultry production has developed and occupies a place of pride among the livestock enterprises due to its rapid monetary turnover**.** This single reason, among others has made poultry production attractive and popular among small, medium, as well as large-scale producers. The poultry industry has become a diverse industry with attendant business interests such as egg production, broiler production, hatchery and poultry equipment businesses among others.

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For industrial birds to express their full genetic potentials, certain basic needs of the birds must be met. These includes appropriate environment, good management, balanced rations, adequate housing and sound disease control program. These needs could be provided through adequate capital bases, which is usually lacking in Nigeria. High cost of feeds, poor quality day old chicks and inadequate extension and training services have been the bane of industrial poultry production in Nigeria (Nwosu and Obioha, 1979). These problems associated with industrial poultry production, make family poultry production in Nigeria popular (Alabi and Aruna, 2005). Family poultry, at 104 million outnumbered all other livestock in Nigeria. Commercial or intensive chicken holding accounts for only 10 million chickens or 11% of the total chicken population of 82.4 million. Thus, families maintain the bulk of poultry in Nigeria under low input, extensive system (Alabi and Aruna, 2005).

Intensive poultry farming provides the optimum conditions for the concentration of pathogens and transmission. The crowding of thousands of birds in an enclosed warm and dusty environment is highly conducive for the transmission of contagious diseases (Collins, 2007). Furthermore, selection of birds for faster growth rate and higher meat yield has left the birds immune system less able to cope with infections and there is a high degree of genetic uniformity in the population, making spread of disease all the more easy (Delany, 2003). The presence of these diseases has created the need for the control of poultry pathogen in the intensive farming system.

Series of solutions have been proffered for the control of these pathogens, for example; further intensification of the poultry industry has been suggested by some as the solution to the spread of disease, on the rationale that keeping birds indoors will prevent contamination (FAO and OIE, 2005). However, this relies on perfect biosecurity and such measures are near impossible to implement, especially in resource poor environments such as Nigeria. Movement of people, materials and vehicles between farms pose threats and breaches in biosecurity are therefore inevitable (Collins, 2007).

Microbiological contamination can be prevented and controlled using proper management practices and healthcare products such as disinfectants (MSU, 2008). The main purpose of disinfectant action is to reduce the number of pathogens in the environment. By reducing pathogen numbers, the potential for disease occurrence in the poultry farm is reduced (Block, 2001). The mode of action of the disinfectant chemicals is usually to disrupt significant cellular structures or processes in order to kill or eliminate the microorganisms (Allen *et al.*, 2006).

Generally, a commercially available disinfectant will exhibit the ability to reduce microbial contamination by several orders of magnitude in a standard test method in order to be approved for use. In use in farms however, not all disinfectants exhibit the activity that one would expect on standard tests (HACCP Manual, 2008). There are many reasons for these but one of the main points to consider is the carefully controlled conditions of the standard test methods, which are simply not the same in the farm environment. Another issue to consider is the disinfection practices at the poultry farms.

In Nigeria, where most of the farm workers are not literate, the dilution of disinfectants may not be carried out according to the producer's directives. In addition, the poor economic conditions of the poultry farmers may cause them to use disinfectants based on lower cost considerations and not on effective prescriptions that may attract higher costs. These lapses result in increased disease problems in intensive poultry production in Nigeria. Biosecurity measures, which include cleaning and disinfection in the poultry industry are critical to the production process and the efficacy of the disinfectants used is frequently debated (Herrara, 2004). In evaluating disinfection process therefore, it is important to consider the type of microorganisms present as well as the physical characteristics of the water in use at the farm. These factors vary from farm to farm and they determine efficacious disinfection (Jeffrey, 2005). Furthermore, the different disinfectants that could be used in a farm could be evaluated in the laboratory using microorganisms isolated from the farm instead of reference cultures; employing dilutes of the water used daily in the farm under question and comparing different disinfectant products under identical conditions of time and temperature.

This paper reviews the importance of disinfection and biosecurity controls of avian microbial pathogen infections in Nigeria.

POULTRY PRODUCTION IN NIGERIA

The poultry industry in Nigeria is a major step to efforts aimed at furnishing the needed high quality protein to Nigerians through meat and egg supply. Poultry production in Nigeria has increased tremendously in the last few decades (FAO, 2000). Over this period, successive governments encouraged the development of large scale modern poultry enterprises. Poultry production is attractive because birds are able to adapt easily, have low economic value, rapid generation time and a high rate of productivity that can result in the production of meat within eight weeks and first egg within eighteen weeks of the first chick being hatched (Smith, 1990). The sudden rush into poultry production in Nigeria has led to the development of an unplanned and unregulated industry numerous attendant problems. The industry is essentially a "biocameral" production system in which the traditional methods of poultry keeping exist side by side with the commercial system. Dominant species include chicken, turkey, duck, geese, guinea fowl, other domesticated waterfowls and game birds.

The traditional system involves the use of mostly multipurpose indigenous or local chickens, which are found in practically every household in most Nigerian rural and peri-urban communities. The applicable production technology is simple and more natural, affording the birds freedom to roam extensively and literally serving as community scavengers in search for food and water for sustenance (Oluyemi and Robert, 1995). As the birds have not been subjected to deliberate selection and breeding procedures, their performance indices, determined as growth rate, mature body weight, offspring livability, live weight gain, feed efficiency, hen-day egg average etc are lower than observations in their imported counterparts. In this regard the indigenous chickens currently have less to offer to the industry in terms of commercial production advantages as compared to the exotic birds (Akinoku and Dettmers, 1977).

Features of the commercial poultry production system: Poultry production is a relatively novel commercial venture in Nigeria. It has distinguishing features of a predominant population of imported breeds, hybrids and crosses, which have been adapted to the intensive production (Akinoku and Dettmers, 1977). The flock therefore requires suitable housing, offering ample ventilation, temperature and humidity levels. The value of formulated feeds, adequate potable water, good sanitation and appropriate preventive and curative medications are also emphasized.

Housing is provided as deep litter or battery cage systems along with expectations of satisfactory feeding and management regimes. However, the relatively standard performance of exotic poultry under the Nigerian environment is associated partially with the problem of acclimatization experienced by many temperature type animals imported into a humid tropical environment (Nwosu and Obioha, 1979).

DISEASE PROBLEM IN POULTRY

Poultry provide globally important sources of animal protein and are amongst the most intensively reared of all livestock species. Diseases of poultry are therefore of major concern, both locally and on an International scale. Disease is defined as departure from health, and includes any condition that impairs normal body structures and functions. Disease results from a combination of indirect causes that reduce resistance or predispose animal to catching a disease, as well as the direct causes that produce the disease (Damerow, 1994). Direct causes can be divided into two main categories, infectious and noninfectious. Some of the non-infectious conditions may result in reduced immune responses (eg problems with nutrition), or increased contact with infectious organisms (e.g. poor housing and management), and will lead to increased incidences of infectious disease.

In contrast to modern poultry production, a range of disease occurring at the same time often characterizes village-based poultry production. Most often free-range poultry have sub-clinical infections with a high number of endoparasites and ectoparasites (Permin and Perderson, 2002). The low productivity in traditional system is mainly due to high mortality, which is caused by poor management, disease, lack of nutritional feeding and predators. In traditional system, the mortality has been estimated to be in the range of 80-90%, within the first year after hatching (Permin and Hansen, 1998). In most family poultry flock therefore, disease is an important problem. Diagnosis, treatment and/or prevention of diseases are of major importance to any attempts at improving productivity. In commercial production systems chickens are therefore routinely vaccinated against major diseases such as Newcastle disease, Mareks disease, infectious bronchitis, avian influenza and others, depending on the specific situations and recommendations in each country. This is however not usually so with the traditional system.

Reservoirs of infection: In order to cause infection in an animal, an organism needs to be introduced from a reservoir, where the disease-causing organism survives, and may multiply. Transmission may be direct or indirect via a vector, or other intermediate hosts. Reservoirs may also be inanimate, such as water or soil (Permin and Hansen, 1998).

Animate or living and inanimate reservoirs of infections: The animate reservoirs include other domestic poultry – chickens, duck, guinea fowl, turkeys, geese; wild animals, including rats and other rodents; wild birds, including caged birds; other domestic livestock; Humans; snails, slugs and earthworms, arthropods such as fleas, mites, lice, mosquitoes and other biting flies. In some cases insects that are eaten by the poultry, may serve as reservoirs of infections.

The inanimate reservoirs of infection on the other hand include feed supplied to poultry, which may contain fungi, bacteria or toxins. Water is essential but must be supplied clean. Stagnant or dirty water that include organic matter may include large number of bacteria, fungi or protozoa. Soil, litter and dust which may contain spore bearing organisms (eg fungi or bacteria) can invade the body through wound; and Housing or other structures used by the poultry that are not kept sufficiently clean, or not adequately ventilated.

According to (Permin and Hansen, 1998), a vector is typically an organism, for example an insect that carries disease organism on its body from which it spreads the disease to other susceptible life forms. Carriers on the other hand are animals that are infected with disease causing organisms, which spread them to other but are not sick or do not show symptoms.

CAUSES OF POULTRY DISEASE

This can be divided into six groups, namely those caused by bacteria, viruses, fungi, parasite, toxins and allergies. There are also those resulting from nutritional deficiencies, poor housing and management and through stress. Whichever is the cause of the disease, the signs could be seen in various regions of the poultry body.

Economic and public health importance of poultry diseases occurrence: Traditional and commercial poultry productions are important in supporting the livelihood of most Nigerian rural and urban communities. Throughout the developing world, the greatest impart of poultry in sustainable development designed to help the growing population is enhancement of poultry production system. Poultry diseases are crucial constraints to this. Poultry diseases remain of major economic and public health importance. In recent years public health concerns for poultry disease have increased (Amos, 2006).

Human health is inextricably linked to animal health and production. The link between human,

poultry and the environment is particularly close in developing region where poultry provide quick source of money as well as protein (meat and egg). In both developing and industrialized countries, however this can lead to serious risk to public health with severe economic consequences (Permin and Perderson, 2002).
Outbreak of poultry disease such as highly pathogenic H5N1 Avian influenza in the world had immediate to severe consequences for the agricultural sector. Human cases, with a high fatality, have been reported in many countries, Vietnam and Thailand with very widespread outbreaks in poultry (Okoli, 2007).

It can be anticipated that human cases will also be detected in other countries where outbreaks in poultry are rapidly spreading. To date no human to human transmission is known to have occurred (Collins, 2007). However, the continuing presence of infection in poultry may also create opportunities for the emergency of a new influenza virus, subtype, with a capacity to spread easily among humans, thus making the start of an influenza pandemic. Should this rare event occur, it would have serious consequences for human's health throughout the world. For this reason, public health concern about the present H5N1 situation must be given the highest priority. Other prevalent diseases of poultry are equally of public health concern and may include salmonellosis, *E. coli* 0157, campylobacter and mycotoxins infections.

Salmonella specie is an important cause of infection in both human and animal. Asymptomatic salmonella enterica serovar enteritidis carrier state in poultry has serious consequences on food safety and public health due to the risks of food poisoning following consumption of contaminated products (Sadeyen *et al.,* 2004). Although food-borne diseases caused by salmonella species are representative of salmonella infection in man, bacteremia and other invasive disease are also caused by salmonella species (Rodrique *et al.,* 1990). Investigation of outbreaks and sporadic cases have indicated repeatedly that the most common source of enteritidis infection are undercooked or raw eggs, and contaminated poultry (Trepka *et al.*, 1999).

Escherichia *coli* 0157 can normally be found in the gastro-intestinal system of a range domestic animal, including poultry. A study carried out by (Akkaya *et al.,* 2006) to determine the prevalence of *E. coli* 0157. H7 on various portions of chicken carcasses, obtained from retail markets and poultry shops in Turkey showed that *E. coli* 0157. H7 was isolated from 2 of the 190 samples examined. Both isolates were found to be capable of synthesizing verotoxin 1 (VTI) and verotoxin 2 (VT2), which are the main determinants of the disease caused by *E. coli* strain. These two toxins are produced by several serotypes of *E. coli*, but bloody diarrhea diseases of humans are mostly caused by *E. coli* 0157.H7, which is one of the *E. coli* group (Riley *et al.,* 1983). In addition to hemorrhagic colitis, this serotype is also recognized as the cause of diarrhea – associated forms of hemolytic ureamic syndrome, and thrombotic thrombocytopenic purpura in humans (Akkaya *et al.*, 2006). Since the first isolation of *E. coli* 0157.H7 from an outbreak of human bloody diarrhea in 1982 (Akkaya *et al.,* 2006), it has been reported from hundreds of sporadic cases and outbreaks in more than thirty countries throughout the world (Carter *et al.,* 1987).
Campylobacter species are recognized worldwide as the major cause of human enteritis (Hascelik *et al.*, 1991). Although several animal species have been shown to carry campylobacter and a variety of vehicles of human infection have been demonstrated (Atabey and Corry, 1997). Avian carriage of campylobacter has been regarded as a potential to human health, either through consumption of undercooked carcass or by contamination of water supplies (Varslot *et al.*, 1996).

Mycotoxins are secondary metabolites produce by fungi of various general when fungi grow on agricultural products. Many mycotoxins with different chemical structures and widely differing biologic activities have been identified (Orriss, 1977). Mycotoxin may be carcinogenic (e.g. aflatoxin B1, Ochratoxin A, fumonisin B1 (Orriss, 1977). Various animal species metabolize mycotoxins in different ways in poultry species it is rapidly excreted. Mycotoxins or their metabolites can be detected in poultry meat and eggs. Residues in poultry products of carcinogenic mycotoxins such as aflatoxin B1, M1 and ochratoxin A, pose a threat to human health and their level should be monitored and controlled (Orriss, 1977).

Recent experience has also shown that measures for the control of this zoonotic disease aimed at halting further spread in poultry and minimizing economic losses, need to be closely coordinated with measures that minimize the longer term risk to human health (WHO, 2007). In the present situation measures aimed as eliminating the disease in poultry will also reduce the presence of the organism in the environment and thus reduce opportunities for human exposure and infection.

The economic importance of poultry diseases such as New castle disease, infectious bursal disease, coccidiosis and fowl typhoid among others cannot be over emphasized. These poultry disease together with all major zoonotic diseases prevent the efficient production of food of animal origin, of much needed proteins and create obstacle to international trade in poultry and poultry products they are thus an impediment to overall socioeconomic development.

CONTROL MEASURES

Diseases continue to impart the world's poultry industry. Health problems have always been a part of the poultry industry. Some of these can be easily controlled, while others are causing more reasons for concern. However, proper feeding, housing, vaccination, disinfection and hygiene are essential modes of disease control in the management of all forms of livestock farming and poultry, particularly when kept under intensive system. In the strict sense, disinfection consists of destroying disease-producing microbes, e.g. viruses, bacteria, protozoa and fungi, by chemical and physical means. If spores are killed during the process, only then is it said to be sterilization (Mrigen, 2006).

Hygiene involves the setting up of physical barriers to restrict the access of disease causing agents to the flock and to limit the spread of infectious materials in and around the poultry houses. The benefits to be derived from disinfection and hygiene need to be applied equally and efficiently, as negligence of one will invalidate the other (Mrigen, 2006).

Biosecurity: With the advent of intensive farming, multi age flocks are reared in close proximity in some regions, which can encourage the spread of a variety of pathogens. Unless the challenges from the pathogens are controlled through strict management practices, vaccination and medication cannot adequately protect the flock (Teresa, 2001). The great challenge for the poultry industry is therefore how to overcome the direct and indirect threat of the disease agent. This has brought biosecurity to the centre stage of farm management. The use of biosecurity measures helps to reduce the microbial load to zero or near zero in and around the farm premises.

According to Ahsan-ul-Heq (2003) the word "Bio" means life and "Security" means to take care of or to save. It means to stop and tackle every aspect of disease production in the flock. Gillinsky (2006) defined Biosecurity as it pertains to poultry farm as the protection of poultry flock from any type of infectious agents, whether viral, bacterial, fungi or parasitic in nature. The Canadian food inspection agency on the other hand defined biosecurity as measures that protect the health of livestock by preventing the transmission of disease.

Adequate biosecurity measures can improve overall flock health, cut the cost of treatment, reduce losses and improve farm profitability (Mrigen, 2006). Biosecurity measures are thus no longer an option but mandatory and practiced consistently to protect the flock from infectious agents that consistently attack extensively housed poultry. As a result, disinfection of the house and equipment has become integral parts of modern poultry management. This has lead to the introduction of a number of disinfectant formulations in this sector and selection of the most suitable one is vital to the provision of proper environment for health and productivity of the flock.

Since the greatest threat to the well being of any creature comes from other creature of the same species, the closer such species crowd together, the greater the risk of disease, which can be passed directly from human to human, animal to animal or through indirect carriers such as contaminated surfaces, feed or water, vermin or insect (Mirgen, 2006). Biosecurity, which excludes disease organisms from the creature's environment is therefore the most effective form of protection, especially those formed using modern production techniques, from viruses, or bacteria, coccidian or fungi. Since disease may spread through recognized vectors of infections, such as the animals themselves, the people who handle them, contaminated food, water, housing and equipment and even the air, modern biosecurity techniques are thus key elements in disease control, providing a healthier environment for the livestock.

Importance of biosecurity: Biosecurity has become recognized as a necessary umbrella concept for various legal interventions and regulatory activities, especially because of the profound impact of the globalization of trade and other aspects of economics. There are currently international agreements protecting animals and plant life and biodiversity such as the conversion of biological diversity (CBD) and the convention on international trade in endangered species (CITES) (Black and Biosecurity experts, 2008). This reflects widely held concern about the future of the planet's natural resources, especially in tropical and subtropical areas. On the other hand, the world trade organization (WTO), through its agreements, especially the agreement on the application of sanitary and phytosanitary measures (SPS) has provided an enforceable international legal framework for ensuring that measures to protect human, animal and plant life and the environment are consistent with free trade (Black and Biosecurity experts, 2008).

Again, according to Black and Biosecurity experts, (2008), the approach to biosecurity issues is manifold and may include:

- Provision of national regulatory programs with measures based as much as possible on international standards set by the appropriate organization for the sector.
- Application of measures that are proportionate to the risks of importation of harmful organisms and chemical substances, when the risk have been identified and assessed through scientific means and when international standards are not available.
- Harmonization of measures between countries.
- Integration of regulatory frame works across sectors, e.g. having agricultural health laws and regulations and enforcement rather than having separate laws and organization for animal health and plant health and WTO rules.

However, biosecurity as it pertains to modern poultry production is essentially keeping the birds separate from the bug, it is a tool to help minimize the effects of infections and decrease the impact of disease. It should be viewed as part of the solution, potentially reducing the dependency on extensive testing and medication. As such, biosecurity is primarily a management-implemented system. Initial design of a biosecurity system should include expert input from veterinarians, but every person involved in the production process with ultimate responsibilities resting on the farm manager (Gillinsky, 2006) accomplishes implementation and follow through. Farm managers should continually evaluate all areas of operation under their direction. Changes in protocols and procedures must be assessed for risk of introduction of pathogens. A complete biosecurity program includes proper design, training of staff, system wide monitoring and constant update (Gillinsky, 2006).

According to Clarke (2006) Steps taken by a production team implementing a biosecurity program includes:

a. Define objective – Example goal – free from *Salmonella enteritidis* and *S. typhimurium*.
b. Agree on controls – Define and identify potential sources of these organisms.
c. Establish standard operating procedures – these should be farm specifics, with sufficient details required for future training.

d. Document by self-audit – Record sources and status of stocks, terminal hygiene, vaccine administration, rodent control program and visitor's log.
e. Undertake statistically valid monitoring of effectiveness.
f. Review flock status on depletion – Problems may mean that standard operation procedures need further development or objectives need modification.
g. Review objective – This is a continuous process.

Initially, biosecurity begins with the physical layout of the farm and the production cycle. Production sites should be isolated from other production facilities so that if problems occur, spread is minimized. Sites with feed mill, breeders, broilers, rendering plants, slaughter houses and hatcheries offer some economics in organization but makes the implementation of effective biosecurity very difficult (Gillinsky, 2006).

"All in-all out" strategies effectively stop the carryover of fragile pathogen on site. This effect is further enhanced by modernized facilities and effective cleaning and disinfection. Biosecurity therefore is based on the simple idea that disease cannot occur if the pathogen that causes the disease is not present at the right time. This task to exclude pathogens is the responsibility of everyone involved in the production process including feed miller, farm electrician, the veterinarian, the egg collector, the crate wash operator and the truck driver. Training to make staff understand biosecurity and documentation of biosecurity protocols is essential. Critical review of these processes by everyone involved and external audit is needed continuously.

The rewards of a sound biosecurity system are poultry production system well protected against known and unknown health threats, lowered risk of evolving resistance to current mediation and a sustainable production system.

CURRENT POULTRY BIOSECURITY SITUATIONS IN NIGERIA

Up to date and appropriate legal and regulatory frame works for biosecurity are essential for poultry and poultry products and to gain access to export markets for the sustainable exploitation of poultry and poultry products. According to Black and Biosecurity experts (2008) many developing countries, especially Nigeria and other emerging economies, provision for biosecurity are usually inadequate for a number of reasons such as:

- Outdated laws and inadequate legal infrastructure.
- Lack of resources, budget and infrastructure for inspection and enforcement.
- Poor cooperation between agencies.
- Lack of technical resources and infrastructure for risk assessment.
- Lucrative markets for goods, which are unabated or damaged biodiversity (Black and Biosecurity experts, 2008).

If these issues are not addressed, developing countries will remain at a disadvantage in world trade and their poultry and poultry products will be at risk of rejection or unscrupulous exploitation.

HAZARD ANALYSIS, CRITICAL CONTROL POINT

The DuPont biosecurity programmed approach to poultry farm hygiene has been developed over many years with the collaboration of leading poultry producers around the world (www.2dupont.com) DuPont biosecurity products have been designed to work effectively under practical farm conditions helping to control the buildup of disease challenge and the losses in productivity and profitability that this could bring. DuPont biosecurity products and procedures have been developed to maximize the benefits achievable through effective biosecurity and to be consistent. HACCP (Hazard Analysis, critical control point) principles are the seven point systemic approach to food safety adopted across the industry (www.2dupont.com).

HACCP is food production, storage, and distribution monitoring system for identification and control of associated health hazard aimed at prevention of contamination instead of end product evaluation (Tompkin, 1990). HACCP strategies identify the areas where pathogens may enter the system, ways to eliminate them and the methods to show that the chain of production is being continually and consistently audited. This is achieved by dissecting every procedure in the production chain (Tompkin, 1990). Currently the production chain has been dissected into seven HACCP principles.

Principle 1: hazard analysis: To identify hazards of both microbiological and physical nature at each step in the process, from receiving through the delivery, such as salmonella, campylobacter or Gumboro virus.

Principle 2: critical control points (CCPs): At CCP's, action can be taken to reduce or eliminate the hazard within the poultry farm. These are control point at which pathogens reduction can take place as part of a biosecurity program. Points 1-6 form part of a continuous program with terminal disinfection at the end of each cycle as shown in table 1. The DuPont biosecurity program provided full details of the action to be taken at each control point, with terminal disinfection broken down into a number of stages for effective control.

Table 1: Critical control points 1-6

Site security	Transport sanitation, wheel dip and foot dips
Personal hygiene	Protective clothing's, hand hygiene and showering in and out
Water system	Disinfect the drinking water
Aerial	Fogging the house to control air borne pathogen
Litter	Clean litter can be sprayed to reduce infection
Rodent control	Integrated past management, (IPM) program
Poultry house	Terminal disinfection program

Source: DuPont animal health solution Europe (2004)

Attention must be paid to personal hygiene throughout the process, with the use of protective clothing, hand hygiene, disinfectant foot dip and showering in and out where possible.

Principle 3: critical limits: Establish acceptable limits for each hazard identified. Cleaning and disinfecting in accordance with DuPont biosecurity program will ensure that microbiological hazards meet those limits. Table 2, shows suggested critical limits of disease organisms following disinfection. Total viable counts are the total number of micro-organisms cultured and the presence of salmonella specifically.

Primary areas are those which have most organic challenge, such as floors and vents. Secondary areas are those which have less organic challenge, such as walls, posts, feeders and drinkers (www.2dupont.com).

Table 2: Critical limits of disease organism following disinfection

	Satisfactory		**Doubtful**		**Unsatisfactory**
TVC primary areas	0-100	100-500	500-1000	1000-2500	2500 +
TVC secondary areas	0-10	10-50	50-100	100-300	300 +
Salmonella presence	Negative				Positive

TVC = Total viable count per in Cm^2; Source: DuPont animal health solution Europe (2004).

Principle 4: monitoring: Observation and measurement of cleaning and disinfecting to ensure the critical limits are met at each step. Four key areas for control of contamination have been identified.

1. Hard surface: Concrete floors, aprons and walls.
2. Porous surface: Earth floors and timber.
3. Equipment: Feeders and drinkers.
4. Movable equipment and personnel.

Principle 5: correction: Action must be taken if the critical limits are not met at any step. Review the application procedure to ensure that it is in accordance with DuPont guidelines (www.2dupont.com).

Principle 6: recording: Records must be kept, demonstrating that the biosecurity programme is in place, implemented correctly and continuously. Records should be kept of products used for critical limits, cleaning schedules and any corrective actions taken, (www.2dupont.com).

Principle 7: verification: Test and procedures should ensure the HACCP system is working properly. This is often performed by an outside person or organization, for example, third party verification of bacteriology test, calibration checks and dosing tests.

DISINFECTANTS AND DISINFECTION

Disinfectants are anti-microbial agents that are applied to non-living objects to destroy micro-organisms, the process which is known as disinfection, (Allen and white, 2006). Disinfection may also be defined as cleaning an article of some or all the pathogenic organism, which may cause infection.

The first disinfectant, carbolic acid, better known today as phenol, was introduced into the operating room by Joseph Lester in the late 19th century (HACCP Manual, 2008). As a result, post-operative infections were dramatically reduced and the science of disinfection was born. Today disinfectants are widely used in health care, food and pharmaceutical sectors to prevent unwanted micro-organisms from causing disease (HACCP Manual, 2008). Man's desire to end disease has led to the development of many different chemical compounds that kill pathogenic micro-organisms. Disinfectant chemical acts to disrupt significant cellular structures or processes in order to kill or eliminate micro-organisms.

Understanding the terms used to describe microbial control is important when selecting the appropriate action for eliminating disease causing organisms. Three terms commonly used but often misunderstood are sterilization, disinfection and sanitation. According to MSU (2008), sterilization is the destruction of all microorganisms (bacteria, fungi, virus etc), while disinfection is the destruction of all vegetative form of micro-organisms. Also, sanitation is the reduction of pathogenic organism numbers to a level at which they do not pose a disease threat to their host. Most agricultural, veterinary and food users are aiming for disinfection since their facilities are not designed for sterilization.

In disinfection, it is extremely important to remove as much organic matter as practicable from surfaces to be disinfected. This is followed by thorough cleaning, using warm water and appropriate cleaning aides. Several considerations must be remembered when using any disinfectant to maximize its effectiveness. According to Gamage (2003) some of these general considerations are –

- Few disinfectants are effective instantaneously.
- Each requires a certain amount of time to bond with the microbe and exert a destructive influence.
- Consider their effectiveness on organisms that are of greatest concern.
- The disinfectant must be compactable with the planned application i.e. type of surface being treated and residual activity requirements.

With the growth in concern over antibiotic resistance, there have been a number of studies attempting to demonstrate a similar resistance to disinfectants in multi-drug resistance bacteria. Studies have shown that in some cases adaptations can occur that provide resistance to low levels of disinfectants however, the levels of disinfectants that these bacteria can "resist" are many times lower than the recommended use levels (HACCP Manual, 2008). Generally, the resistance of micro-organisms to disinfection is due to the existing cellular structures and life cycle adaptations. It is important to read the label carefully and follow the manufacturer's direction to achieve the best results (HACCP Manual, 2008).

TYPES OF DISINFECTANTS AND THEIR CHARACTERISTICS

Alcohols: In the health care setting "alcohol" refers to two water soluble chemicals ethyl alcohol and isopropyl alcohol (Gamage, 2003). Its mechanism of action is the dilution of the phospholipids at the membrane of the microorganism resulting in leakage (Denyer and Stewart, 1998). They have wide germicidal activity, non-corrosive and flammable. Alcohol provides limited activity in the presence of organic matter. They have limited residual activity due to evaporation (EPA, 2009). It is excellent for disinfecting instruments but too expensive for use in the hatchery and poultry farms (MSU, 2008). Examples of alcohol are ethanol and methylated spirit.

Halogens (iodine and hypo chlorides): Iodines and iodophors are well established chemical disinfectants. These compounds are bactericidal, sporocidal, virucidal and fungicidal but require prolonged contact time and they are corrosive (MSU, 2008). They have low activity in the presence of organic matter, poor residual activity, low toxicity, may stain surfaces. They are low in cost but require frequent applications. They act on amino groups in proteins of the microorganisms, inhibiting their metabolic processes. They are used in hatcheries for walls and equipment disinfection. Examples are Beladine, Isodyne, Iosan, weladol, tincture of Iodine and povidone iodine.

Hypochlorites on the other hand are the most widely used of chlorine disinfectants (Gamage, 2003). They have a broad spectrum of antimicrobial activity, are unaffected by water hardness, are expensive and fast acting and have a low incidence of serious toxicity (EPA, 2009). The halogen acts on the amino groups in the protein of the micro-organisms inhibiting their metabolic processes (Denyer and Stewart, 1998). Chlorine is used for water disinfection, example are: chloramin-T Halozone, virkon and Clorox.

Aldehydes (Gluteraldehyde and formaldehyde): Aldehydes have wide germicidal activity (MSU, 2008). Gluteraldehyde are bactericidal, virucidal, fungicidal, sporocidal and parasiticidal (Gamage, 2003). They are partly inactivated by organic matter and have slight residual activity, are moderately toxic and of moderate cost (EPA, 2009).

Formaldehyde is used as disinfectant and sterilant both in the liquid and gaseous state. It is bactericidal, tuberclucidal and a potential carcinogen (Gamage, 2003). The aldehydes act on the biomolecules (eg proteins, RNA, DNA) containing amino acid in the micro organism resulting in metabolic and replicative inhibition (Danyer and Stewart, 1998). They are used in the hatchery, Examples are formalin and formaldehyde.

Quaternary ammonium compound (QAC): They have limited germicidal range (MSU, 2008), not spirocidal, effective against vegetative bacteria, fungi and viruses (Gamage, 2003). They have reduced efficiency in the pressure of organic matter, soap, detergents, hard water and salts (Jeffrey, 2005). They are non-militating, non-corrosive and have low toxicity (EPA, 2009). QACs act on the cytoplasmic membrane of the microorganism, resulting in leakage, respiratory inhibition and intracellular coagulation (Denyer and Stewart, 1998). They are widely used in commercial hatcheries. Examples are warden, zephiran, Roccal Hi-Lethol and Germex.

Phenols: Phenolics are the active ingredients in some house hold disinfectants (Gamage, 2003). They are also found in some mouthwashes and in disinfectant soap and hand washes. Phenol is probably the oldest known disinfectant as Lester first used it, when it was called carbolic acid (HACCP Manual, 2008). They have wide germicidal activity and low corrosiveness (EPA, 2009). They are low to moderate in cost. They act on transmembrane pH gradient of the organisms, resulting in leakage and disruption of transport (Denyer and Stewart, 1998). Their common uses in commercial animal production unit include: hatchery equipment, sanitation and footbaths. Examples include Lysol, pore-bol, crebi-400, environ cresol and Tek-Trol.

Oxidizing agents (Hydrogen peroxide and potassium permanganate): They have moderate to wide germicidal activity and are not sporocidal (MSU, 2008). They are rendered ineffective in the presence of organic matter, are moderately corrosive and are of limited toxicity (EPA, 2009). They act on the enzyme and protein thiol groups of the micro-organisms resulting in metabolic inhibition (Denyer and Stewarts, 1998). They are used in commercial poultry operations. Examples include, hydrogen perioxide and oxone

Natural agents of disinfection: |Natural forces that reduce the pathogen load in the environment are important and can often be used to advantage. These include sunlight, heat, cold, drying (desiccation) and agitation (Jeffrey, 2005).

The ultra violet rays of sunlight are tremendously potent in killing microorganisms. This is very helpful outside of buildings, but unfortunately, the ultraviolet rays cannot pass through glass, roofs or dust (Jeffery, 2005). Drying from fresh air and wind will also kill pathogens, particularly when they are exposed in the process of cleaning. Extremes of temperature (below freezing or above 85 degrees f.) will kill microorganisms, although susceptibility to temperature changes varies widely

DISINFECTION OF POULTRY FACILITIES

Having an effective cleaning and disinfection program is a crucial step in every poultry biosecurity program. A cleaning and disinfection program should be instituted after a poultry building has been depopulated and before restocking occurs on the farm. The main purpose of cleaning and disinfection program is to reduce the number of pathogens in the environment. By reducing pathogen number, the potential for disease to occur in the poultry flock is also reduced (Block, 2001).

It is important to identify the pathogens that should be eliminated, as certain disinfectants are ineffective against certain disease agents. Hence, to maximize disinfection program, it is important to identify what disease agent(s) to be eliminated or reduced in the farm. The first step in any disinfection program is cleaning, which is the physical removal of organic materials such as manure, blood, feed, and carcasses. It is important to remove these organic materials before the disinfection because disease agents are often protected in these materials and can survive the disinfection process.

The cleaning process includes dry cleaning and wet cleaning steps. According to Russel *et al.* (1984), dry cleaning involves the physical removal of organic materials, while wet cleaning as its name implies involves the use of water. There are four basic steps in wet cleaning process. They are soaking, washing, rinsing and drying. Although not always necessary, detergents can be used in the wet cleaning process.

The final step of ensuring a proper cleanup is having the wet areas of the building dried quickly. If the building is not dried properly, the excess moisture can result in bacterial multiplying to higher level than seen before cleaning. If done properly a good cleaning can remove 90% of the pathogens (Gordon and Morishite, 2007). The last step in a cleaning and disinfection program is the disinfection process down. This involves the use of disinfectants that will reduce or kill the pathogens. There are several types of disinfectants, and the one chosen should be effective against the disease agent(s) that is being targeted (Koulikovskii, 1984).

SANITATION AND DISINFECTION PROGRAM IN POULTRY FARMS

According to Ahsan-ul-Haq (2003), sanitation is the most important parts of commercial poultry management. It means cleanliness at the farm to prevent outbreak of disease. Jeffrey (2005) stated that sanitation refers to the quality of cleanliness, while disinfection refers to the reduction of pathogen. Reducing the load of pathogens in the environment of the flock will decrease the risk of disease. As stated earlier, disinfectants are chemical agents that kill pathogen on contact whereas cleaning prior to disinfection exposes the pathogen to the disinfectants.

According to Clark (2006), poultry farms should be constructed as isolated from other animal facilities as is possible. The rule has been 1-3 miles from any other poultry facilities. In many of the poultry producing state, this has been difficult to implement. The facilities should be constructed so that they can be easily repaired and they should be kept in a good state of repair to keep birds in and wildlife out. Orientation of the farm should be such that it provides maximum sunlight and ventilation; floor and walls should have a plain surface. There should be no cracks and crevices to ensure complete disinfection (Ahsan-ul-Haq, 2003).

According to Jeffery (2005), before disinfection all bedding, feed and manure should be removed. Loose dirt, cobweb etc should be swept out. All surfaces should be scrubbed with detergent and then rinse out all detergent and organic matter from surface, before disinfection. In disinfection, apply the disinfectant and allow the disinfectant to dry completely. Reapply the disinfectant and allow it to dry a second time.

Water disinfection: Jeffery (2005), states that chlorine is commonly used as a disinfectant for drinking water at a concentration of 3 parts per million (ppm). Concentration up to 10 ppm has been reported to be well tolerated by chickens, while 5 ppm is required for slime control. Chlorination can be done by various methods however; using liquid sodium hypochlorite is the most practicable. Household bleach is diluted sodium hypochlorite. Products vary from 5 to 15 percent sodium hypochlorite. Clorox® is about 5%.

To prepare a stock solution, 1 ounce of Clorox® (or 2 teaspoon of liquid bleach of 15% sodium hypochlorite) is added to one gallon of clean water and mixed in a plastic container that can be sealed shut. For slime control, 1.5 to 2 ounces of Clorox® (or 3 teaspoons of 15% liquid bleach) per gallon of water are needed. According to Jeffery (2005), water chlorination is done by adding 1 ounce of stock solution to 1 gallon of drinking water.

Disinfection of slaughterhouse: FAO (1978) stated that sanitation in the slaughter is the act or process of providing adequately hygienic conditions to ensure a safe, sound, wholesome product fit for human consumption and covers hygienic precautions regarding personal hygiene, process hygiene and cleaning and disinfection.

The current sanitary situation in Nigeria slaughter facilities is not in tandem with this definition (Okoli *et al.*, 2005, Okoli *et al.*, 2006), in a recent studies by Aniebo *et al.* (2008), assessed facilities and operations in Afor Ajala Mbaise Abattoir, Imo State, Nigeria and showed that the site plan and capacity of the abattoir were adequate, but the facilities on ground were grossly inadequate. Abattoir operations were unethical, unhygienic and resulted in the production of contaminated meat, which were sold to unsuspecting consumers. Therefore adequate cleaning and disinfection of slaughter house is important.

The number of microorganism should be reduced to a level that will not cause harmful contamination of food. Choosing the correct disinfectant and method will depend on;

- Surface materials
- Type of processing areas
- Cleaning program
- Disinfection method

The application of disinfectants has to be carried out by low-pressure sprays (Manual Sprays or Sprays carried in the back, mobile pressure containers etc) (Schmidt, 1983)

Human disinfection and vehicle control in poultry farms: The economic consequences of disease outbreak are that they cost poultry producers loss of revenues. To minimize these losses, disease prevention methods must be followed, including practices controlling disease-causing organisms. Gordon and Morishite (2007), states that human indirect or direct contact with poultry is the primary route of introduction or spread of disease in poultry farms. Mobility tasks (as employee, manager or veterinarian), curiosity, lack of knowledge, and negligence are among the factors that can result in human spread of disease. It has been shown that in more than 90% of the cases, people are the cause of disease transmission among poultry farms. In other words, more than 90% of breaks in biosecurity are the result of human activity. Thus, if attention is focused on controlling the movement and disinfection of people, the result may be a significant reduction of disease problems.

According to Gillinsky (2006), staff and visitors should shower, using an antimicrobial soap before entering the farm area. Farm managers should provide staff and visitors with the appropriate protective clothing to wear after showering, including water proof boots and protective overalls. This gear should only be used on the site and needs to be disinfected regularly on the farm premises in washing units designed specifically for this purpose. Where on site disinfection is not possible, specialist contracted laundry services should be used.

When entering and leaving a poultry unit or outdoor site, staff should immediately clean and disinfect boots and wash hands using warm water and an anti-microbial hand soap. Farm management should provide paper towels for drying and ensure that a plastic bag-lined dust bin is located near the sink to collect used towels. Once full, these bags should be disinfected and incinerated.

Monitoring vehicles entering premises for poultry pick up or delivery, feed delivery, fuel delivery etc is also important in disease reduction. Vehicle should be packed away from the production area of the farm on paved gravel or concrete area, if possible should be cleaned and disinfected before entering the farm (Kuney, 2002).

Hatchery disinfection: Cleaning and disinfection are fundamental to effective hygiene in the hatchery. Cleaning can remove 85% of microorganism, preventing their development by removing their food sources, or "dirt". Then the remaining micro-organisms can then be eradicated by disinfection, (PRHT, 2006).

Egg reception: If an egg has been disinfected on farm, they can be moved immediately to the setter trays for storage. Ideally eggs should be disinfected as soon as possible after collection at the farm and upon arrival at the hatchery (Buhr *et al.,* 1993). They must all be disinfected using appropriate warm (38-41^{o}C) suitable disinfectant solution by way of disinfectant spray or fog before setting (Scott, 1993).

Setters: In multi-stage setters, the work of contamination is higher and cleaning and disinfection is more difficult than in single stage machine (www.2dupont.com). It is therefore recommended to fog disinfectant into the setter after new eggs have set or transferred. Using a mechanical unit/cold fog generator knapsack sprayer or pressure washer, on a fire moist setting, fog a suitable disinfectant solution into the egg setter until equipment and eggs surfaces are wetted thoroughly (www.2dupont.com).

If egg explodes in the setter (bangers or rots), the level of the contamination in the setter will rise dramatically unless a rapid disinfection is administered. Whether in single or multi-stage setters, fogging an appropriate disinfectant solution directly on the affected area, followed by daily fogging of the setter until transfer will reduce problem (www.2dupont.com).

Setter machines, setter rooms, candling and transfer area after egg transfer stages: According to Casey (2003) cleaning and disinfection for walls, floors, ceilings, windows, fans, ducting and machines:

1. Remove dust and debris from al surface and dispose of accordingly.
2. Using a pressure washing system, either spray or foam an appropriate detergent solution to all surfaces. Where necessary, scrub walls and floors to remove stubborn soiling. Leave to soak for 20-30 minutes before rinsing.
3. Removal of any excess water from the floors using a squeezer before leaving to dry.
4. Switch the setter machine on and leave to warm up.
5. Apply an appropriate broad spectrum disinfectant solution using pressure washing system on a low pressure setting (300 pd) to all surfaces of the setter and leave to dry.

The operational biosecurity must be followed and motivate the personnel through implementation, control and feed back of the result (www.2dupont.com). Correct hygiene management and disinfection will lead to the ultimate goal every hatchery chicks and thus more profit.

Egg disinfection: A study undertaken by Scott *et al.* (1993) examined the potentials of ultraviolet (UV) light as a user friendly safe method of sanitizing hatchery eggs and as means to "scrub" circulating air in the incubator

Eggs treated with formalin before setting and then incubated in UV light with an air filtering system had lower bacterial counts and higher hatchability than those without the light (77.4 vs 71.4%), (Buhr *et al.,* 1993) and late embryonic mortality was reduced to nearly 30%. Pre-incubation egg treatment with sanitizers having a residual effect would also be helpful in preventing recontamination during incubation (Scott and Swetnam, 1993).

Timing of egg disinfection: The type of organism involved and the immediacy of treatment will likely have a significant influence on the success of the disinfection. According to the work done by Cox and Bailey (1991) in which the shell of hatching eggs was inoculated with a strain of salmonella. The eggs were then treated with one of the several disinfectants at 1 min, 5min, 4 hours and 24 hours after inoculation. In the average there was a 77% reduction of the incidence of contaminated eggs when treated within 1 min, 64% reduction for treatment within 5 min, 45% reduction for treatment within 4 hours and less than 10% reduction for treatment within 24 hours. Thus, the time lapsed from contamination to treatment with a disinfectant is crucial to the success of the disinfection (Scott and Kinsman, 1993).

According to Buhr *et al.* (1993), immersion of eggs in disinfectant was more effective than a spray, which in turn was more effective than foam application. Gluteraldehyde, quaternary ammonium and a viricide were ineffective; poly-hexamethyene biguanide hydrochloride (PHMB), hydrogen perioxide (1%) and phenol (2%) were most effective resulting in 95%, 94% and 80% reductions, respectively, in contaminated eggs with 1 min post inoculation treatment and 95, 44, and

69% reduction with the 5 min treatment. It is obvious that the results of disinfection are greatly influenced by the timing of treatment and the type of disinfectant (Buhr *et al.*, 1993).

Furthermore, the beneficial effect of disinfection on hatchability may be disappointing. In a study made with chicken eggs (Cox and Bailey, 1991), the effect of disinfection of nest clean or dirty eggs ranged from no effect on hatchability to an increase of 2 percentage points for sanitized eggs. A Canadian study examined 23 sanitizers/disinfectants for positive and negative characteristics in respect to their use in hatchery (Scott and Swetnam, 1993). The type of product tested were Ozone, quaternary ammonium iodine complexes, phenols, halogens, aldehyde, salts, alcohols, acids and various combinations. Others were formaldehyde, glutacide, quat 800, germex, quam, super quam, tryad, egg wash, coverage 25.6, basic G&H, 10cide-14, 10dophor, lysoret, 1-stroke, Tektrol, D.O.C, hypochloride or bleach, chlorwash, bioguard, H. perioxide, virkon, sanimist and chlorwash.

Most of the compound tested should be used with protective clothing and precautions should be taken against inhalation and eye and skin contact. Product which were deemed to have potential as severe hazards to eye, skin and respiratory system were bleach, formaldehyde, ozone and tektrol (Scott, 1993).

Feed mills and feed materials disinfection: It has been established that the production and delivery of quality feed is vital to the success of any animal production operation. It has also been recognized that infectious agents are most effectively spread in commercial production situation via either contaminated birds or contaminated feed (Jones, 2002).

Feed mills and feed delivery trucks are key links between commercial egg and poultry facilities and poultry workers. Delivery of feed to poultry farm can distribute disease agents to commercial flocks. Disinfection is to prevent spreading of disease agents from the feed manufacturing facilities, trucks and employees to poultry farms. According to (Kuney, 2002), feed mills should have clearly stated visitor policy. Visitors to the feed processing and handling areas should be limited only to individuals essential to the operation of the mills. Foot baths and dip mats with disinfectants should be placed wherever truck drivers will be entering or exiting the mill.

For bulk feed delivery trucks, thorough washing with a hot high-pressure spray containing a detergent is recommended. Following the wash, all surfaces should be thoroughly rinsed with a hot, high-pressure water spray. After all surfaces have been cleaned and usually inspected, a disinfectant can be applied. It is important to allow the disinfected surfaces to dry before leaving the feed mill (Kuney, 2002). Traffic pattern should be developed that separates contaminated trucks coming back to the mill after a delivery, from trucks that have been cleaned and disinfected and are about to leave the mill to make a delivery.

Pelleting most often is being used as a form of contamination control in feed processing. The heat of the pelleting process reduces the microbial count (Jones, 2002). Although many feed manufacturers rely on the pelleting process for microbial disinfection, few published studies have examined the process under field condition.

CONCLUSION

Disease outbreaks cost the Nigerian Commercial poultry industry millions of naira yearly in lost revenue (Onah, 2003). These outbreaks could be minimized by prevention of bio-contamination. Measures to enhance safety of food and good quality poultry products from farm to table are key concerns for all involved in producing and processing poultry products. In-adequate prevention of bio-contamination may lead to farm wide epidemics of highly pathogenic and exotic disease (Onah, 2003).

Global concerns about poultry pathogen play a prime role in poultry exports and food policy decisions in international trade. If Nigeria poultry farmers will sustain asses to domestic and international trade, there is need to think seriously about disease control. Although vaccination and antibiotic usage are the main stay in infectious disease control, prevention of bio-contamination is important because some disease causing organisms have no effective vaccine or are subject to re-occurring antibiotics resistance. Disinfection to prevent contamination therefore remains a viable alternative.

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