International Journal of Animal and Veterinary Advances 7(3): 55-61, 2015
ISSN: 2041-2894; e-ISSN: 2041-2908

Submitted: January 28, 2015 Accepted: March 4, 2015 Published: July 20, 2015

Antibiotic Residues in Edible Poultry Tissues and Products in Nigeria: A Potential Public Health Hazard

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Abstract: Antibiotics are used by the veterinarians and poultry industry to enhance growth rates, health of the birds, feed efficiency, egg production and for therapeutic reasons to reduce the incidence of poultry diseases. Antibiotics had been used in poultry production for both therapeutic and prophylactic purposes. Most poultry farmers in Nigeria have employed the use of various antibiotics with or without the guidance of veterinarians. Although antibiotics benefit most of its uses, the illegal use of these drugs has led to the accumulation of toxic antibiotic residues in edible poultry products destined for human consumption. And this poses a major threat and hazard to the public that could be toxicological, microbiological or immunological. Several analytical techniques are available to screen edible poultry products with levels of toxic antibiotic residues. Drug withdrawal period and maximum residue level of antibiotics should be strictly observed in treated birds before any poultry product (meat or eggs) is passed "wholesome" for human consumption. There are still few researches addressing this major public health problem coupled with lack of awareness in Nigeria. Therefore, there is need for public enlightenment campaign on the dangers of antibiotic residues in edible poultry tissues and products to the teeming populace and restriction and regulation of indiscriminate use of antibiotics in poultry production and industry to curb the incidence of this public health hazard in Nigeria.

Keywords: Antibiotics, antibiotic residues, Nigeria, Edible poultry tissues, Public health hazards

INTRODUCTION

Antibiotics are naturally occurring, semi-synthetic and synthetic compounds with antimicrobial activity that can be applied parentally, orally or topically (Geidam *et al*., 2009). Antibiotics are among the most widely used veterinary drugs in poultry industry (Simon and Baxter, 2006). They are used by the poultry industry and veterinarians to enhance growth rates, health of the birds, feed efficiency, egg production, or for therapeutic reasons to reduce the incidence of poultry diseases (Dipeolu *et al*., 2002; Donoghue, 2003). Antibiotics have been used in poultry farming for several decades in combating bacterial infections (Olatoye and Ehinmowo, 2009), as growth promoters (Geidam *et al*., 2009) and in prophylaxis (Nisha, 2008). In poultry production, the usage of antibiotics has facilitated the efficient production of poultry allowing the consumers to purchase at reasonable cost high quality meat and eggs (Donoghue, 2003). In Nigeria, a large population of poultry farming is done by the so-called backyard poultry farmers who readily have access to veterinary drugs and always purchase drugs over the counter for administration without veterinary prescription and supervision. This result in the indiscriminate use of these drugs especially in food animals (Dipeolu, 2004). Consequently, the inappropriate use and handling of these antibiotics has led to occurrence of harmful residues in edible poultry tissues (meat and eggs) and other animal products like milk (Olatoye and Ehinmowo, 2009; Shareef *et al*., 2009). Veterinary drug residues in poultry meat and eggs may be produced by exposing chickens to drugs or contaminants in a numbers of ways. These include:

- Illegal or extra-label uses of drugs
- Use of feed unintentionally cross contaminated during feed mixing
- Use of mislabeled feed
- Pesticide, chemical or heavy metal contamination of feed ingredients or water (Donoghue, 1998, 2001; Sasanya *et al*., 2005; Doyle, 2006).

Poultry meat and eggs are extremely important human food commodity. Unfortunately edible poultry

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tissues may be contaminated with harmful concentration of drug residues due to continuous and improper antibiotic usage in poultry industry (Donoghue, 2003; Shareef *et al*., 2009). Human consumption of toxic levels of antibiotic residues in food of animal origins (meat, milk or egg) had caused several pathological defects in man that are of public health importance (Dipeolu, 2004; Doyle, 2006; Nisha, 2008; Shareef *et al*., 2009; Muhammed *et al*., 2009). Therefore, birds or farm animals treated with antibiotics are required to be held for specific withdrawal period until all residues are depleted to safe levels before their eggs and tissues can be used as food for human consumption (Kukanich *et al*., 2005; Olatoye and Ehinmowo, 2009). The occurrence of veterinary drug residues in edible animal tissues remains a global problem (Geidam *et al*., 2009). Several screening analytical techniques are available for monitoring the presence of veterinary drug residues in foods of animals' origin (Heller *et al*., 2002; Sasanya *et al*., 2005; Simon and Baxter, 2006; Tajik and Shohreh, 2006; Nisha, 2008; Muhammed *et al*., 2009; Javadi *et al*., 2009; Shareef *et al*., 2009). Although, in most developed countries close attention is paid on sampling of animal products for chemical residues (Dipeolu, 2004). However, in some developing countries including Nigeria it was reported that food standards and regulations are inadequate and in some cases does not even exist (Dipeolu, 2004; Geidam *et al*., 2009). This is an indication that there are no adequate veterinary public health regulatory control and national programme for monitoring drug residues in foods of animals' origin in Nigeria (Kabir *et al*., 2004; Dipeolu, 2004; Olatoye and Ehinmowo, 2009; Geidam *et al*., 2009). Currently, a large populace of Nigeria is at high risk of the several defects caused by the consumption of meat or eggs from exotic breeds of chickens with toxic levels of antibiotic residues. Therefore, the aim of this review is to evaluate the risk and public health significance of consumption of edible poultry tissues and products with antibiotic residues in Nigeria.

LITRATURE REVIEW

Some commonly used antimicrobials in poultry industry in Nigeria: Antibiotics can be applied in veterinary practice in three ways:

- At sub-therapeutic concentration,
- In a rotating classes of multiple antibiotics at low, sub-therapeutics concentration
- In a gradient sub-therapeutic regimen (Shareef *et al*., 2009).

Some of the commonly used antibiotics today in poultry industries in developing countries like Nigeria are Tylosine, Neomycin, Gentamycin, Tetracyclines (Chlortetracycline, Oxytetracycline), Sulfonamides (Sulfadimethoxine, Sulfamethazine, Sulfathoxazole), Penicillin (Ampicillin), Arsenicals (Roxarsone), Enrofloxacin, Erythromycine (Alhendi *et al*., 2000) and vaccines (Sasanya *et al*., 2005).Chloramphenicol, beta-agonist compound and hormones are not allowed to be used in poultry production in most countries (Simon and Baxter, 2006). However, most antibiotics used in Nigerian poultry industries are labelled in different trade names, some of which are the combinations of two or more chemical substances to make them extra potent. While some are incorporated with several multivitamins. Most of these antimicrobials are administered orally to the birds in drinking water or mixed with feeds (Sasanya *et al*., 2005).

Pharmacology and toxicology of commonly used antibiotics in poultry industry in Nigeria: Veterinary drugs can be administered under prescription to food producing animals for therapeutic, prophylactic or diagnostic purposes (Simon and Baxter, 2006). Emphasis has been placed to ensure that, if veterinary drugs have been administered to animals, they are not present in tissues above their safe Maximum Residue Limit (MRL) or if banned from use in veterinary practice are not present at all (Dipeolu, 2004; Kabir *et al*., 2004; Simon and Baxter, 2006). Most of the antibiotics used in poultry production are administered in drinking water or incorporated in feed. It was reported that following administration these drugs are rapidly absorbed from the gastrointestinal tract of the chicken (Ramadan *et al*., 1992; Alhendi *et al*., 2000). It was also reported that administration of Ampicillin, Oxytetracycline and Sulphadimidine in feed resulted into an immediate increase in concentration of these drugs in plasma from the first day of treatment onward and in the liver, kidney and breast muscle from the second day of treatment onward (Alhendi *et al*., 2000). Factors such as physiochemical properties of the drug, presence of bivalentions in the gut and nutritional sources may affect absorption from the digestive tract of chickens (Gihmam *et al*., 1991; Alhendi *et al*., 2000). Geidam *et al*. (2009) reported that demographic variables like age, sex and species also influences distribution of drugs in tissues of animals. Following absorption from the gastrointestinal tract, penicillin is usually cleared rapidly from the blood via the kidney and into the urine and its metabolism occurs in the liver and kidney (Doyle, 2006). Greater amount of Oxytetracycline dose are absorbed from gastrointestinal tract and widely distributed in the body, particularly in the liver, kidney, bone and teeth; there is little, if any metabolism of this drug in animals or human (Doyle, 2006). Donoghue (1998) reported that in eggs Oxytetracycline seems to preferentially deposit in albumen. Sulfonamides are metabolized vianumerous pathways; the major metabolite is an acetyl derivative

and the primary mechanism of toxicity of sulfonamides is associated with the thyroid and hypothalamus pituitaryaxis (Doyle, 2006). Gentamycin and Neomycin are also not readily metabolized in animals and humans, but is rapidly depleted from the muscle and fat and it tends to persist in the kidney or liver. These drugs cause damage to the kidney and result in hearing loss (Doyle, 2006). Studies have revealed that Streptomycin is not readily absorbed from the gastrointestinal tract of animals and humans, because of its high molecular mass and it is also not metabolized significantly when injected and oral dose of the drug are eliminated unchanged in via feaces. Streptomycin may also have adverse effects on the kidney functions (Doyle, 2006). The most commonly used arsenic compound for poultry is roxarsone. Most of the drug is excreted unchanged but some metabolites have been detected in hen urine (Doyle, 2006). Donoghue (1998) reported the deposition of arsenic in egg yolk. Inorganic arsenic is known to be carcinogenic and may adversely affect the circulatory and nervous system, while organic arsenic is considered less toxic (Doyle, 2006).

Causes of antibiotic residues in edible poultry tissues: Recently there have been some public health concerns on the antibiotic residues in poultry edible tissues and products like meat and egg and the attendant adverse effects of these residues on the public, who directly consume these products. (Doyle, 2006). Failure to adhere strictly to the withdrawal period or the Maximum Residual Limits of antibiotics in poultry production is reported to be the primary cause of antibiotic residues in edible poultry tissues and products like eggs (Dipeolu, 2004; Doyle, 2006; Olatoye and Ehinmowo, 2009). Withdrawal periods ranging from a few days to a few weeks are recommended for approved veterinary drugs (Doyle, 2006). This period vary according to the drug used, dosage, route of administration and animal species. Withdrawal period is defined as the time required for 99% of the birds in a population (treated according to labelled instructions) to be free of the drug residues above the tolerance level. A new veterinary drug is unsafe to be used in food producing animals especially when it is not used in accordance with its approved labelled direction. Therefore, the use of an unapproved new veterinary drug or of an approved new veterinary drug contrary to label direction can lead to toxic residues in poultry edible tissues or eggs (Policy Guide, 2009). When novice uses veterinary drugs, correct dosage is unlikely to be administered and withdrawal period are usually not observed. Lack of proper application and handling of antibiotics can lead to occurrence of residues in food of animal origin (Olatoye and Ehinmowo, 2009). In Nigeria, studies had been conducted on drug administration and residues deposition in the poultry meat and other products (Dipeolu, 2004; Kabir *et al*., 2004; Geidam *et al*., 2009; Olatoye and Ehinmowo, 2009) and other African countries (Muriuko *et al*., 2001; Sasanya *et al*., 2005). They reported that the causes of illegal antibiotic residues in edible animal tissues include the administration of drug through improper route (s), over dosage of drug (s),the use of drug (s) that are not recommended for use in poultry production (e.g., beta-agonist compound and hormone are not to be used in poultry production and Sulfonamides are not to be used in laying birds) (Kabir *et al*., 2004). Maximum Recommended Levels (MRLs) had been fixed for authorized veterinary drugs to ensure consumer safety, such MRLs should not be exceeded if good veterinary practice were used. Most farmers are concerned with cost of production rather than public health risks and therefore could not delay disposing their chickens or eggs for purposes of observing withdrawal period (Sasanya *et al*., 2005).

Techniques for screening of antibiotic residues in edible poultry tissues: Microbiological methods like Agar gel diffusion test are the basis of screening methods for monitoring the presence of veterinary drug residues in food of animal origin (Alhendi *et al*., 2000; Hussein, 2004; Javadi *et al*., 2009). Although they cannot be used to identify individual antibiotics, therefore a positive result should be confirmed with chemical or physical methods (Kirbis, 2006; Javadi *et al*., 2009). Analytical techniques that are used for the screening of veterinary drug residues include Radio Immunoassay (RIA), Enzymes Immunoassay (EIA) (Javadi *et al*., 2009) and Thin Layer Chromatography (TLC) (Simon and Baxter, 2006; Tajik and Shohreh, 2006; Shareef *et al*., 2009; Geidam *et al*., 2009). Confirmatory tests applied to screening samples that require further investigation are usually based on Mass Spectrometric (MS) techniques such as Liquid Chromatography (MS/LC) (Simon and Baxter, 2006; Muhammed *et al*., 2009). Other techniques used for the detection and analysis of drug residues in edible tissues are High Performance Liquid Chromatography (HPLC) (Olatoye and Ehinmowo, 2009; Muhammed *et al*., 2009), Gas Chromatography (Muhammed *et al*., 2009) and Paper Chromatography (Nisha, 2008). In recent years, the demand for increased testing with regard to food safety has led to the development of new technologies for screening of drug residues in food of animal origins. The advent of a Surface Plasmon Resonance (SPR) based biosensor is one of such technologies. This fully automated wizard-driven instrument is capable of analysis of wide range of analytes and it is supported by *in-vitro* diagnostic kits for the screening of several veterinary drug residues (Simon and Baxter, 2006). Solid Phase Micro-Extraction (SPME) and Micro dialysis Methods are also

modern analytical techniques used for drug residues analysis in edible animal tissues (Muhammed *et al*., 2009).

Public health hazards associated with consumption of poultry tissues and products with antibiotic residues: Poultry meat and eggs provide an important source of human nutrition in many developing countries (Sasanya *et al*., 2005). They are considered to be very important in combating the problem of low protein intake of the populace (Dipeolu, 2004). It is expected that each year approximately 220 eggs are consumed on average by each individual in Nigeria (Donoghue, 1998). It is therefore of utmost importance that such food of animal origin be safe and wholesome for human consumption (Dipeolu, 2004; Olatoye and Ehinmowo, 2009). Antibiotic residues in foods of animal origin (eggs, meat and milk) that are meant for human consumption are one of the sources of concern among public and medical health professionals (Adams, 2001; Shareef *et al*., 2009). This is because man is the ultimate consumer of these toxic antibiotic residues in these products (Donoghue, 2003; Dipeolu, 2004; Sasanya *et al*., 2005; Simon and Baxter, 2006; Doyle, 2006; Olatoye and Ehinmowo, 2009; Shareef *et al*., 2009). Pathological effects produced by most antibiotic residues in food of animal origins had been documented by some researchers in the world. These effects have caused significant health problems that might be toxicological, microbiological or immunological (FAO, 1999; Alhendi *et al*., 2000; Cunha, 2001; Botsoglou and Fletouris, 2001; EMEA, 2001; Javadi *et al*., 2009; Olatoye and Ehinmowo, 2009). Health hazards in humans that resulted from the consumption of tissues with toxic antibiotic residues include the transfer of antibiotic resistant strain bacteria known to be food borne pathogen (e.g., *Salmonella spp., Escherichia coli* and *Campylobacter spp.*) to humans (Boothe and Arnold, 2003; Hayes *et al*., 2004; Aarestrup, 2005; Doyle, 2006; Nisha, 2008; Geidam *et al*., 2009; Shareef *et al*., 2009), Immunological effects (Nisha, 2008), imbalance of intestinal micro-flora (Larkin *et al*., 2004; Kirbis, 2006; Javadi *et al*., 2009; Olatoye and Ehinmowo, 2009), Carcinogenicity (Sulfonamides, Arsenicals, Oxytetracycline, Furazolidone) (Sasanya *et al*., 2005; Doyle, 2006; Nisha, 2008; Javadi *et al*., 2009; Olatoye and Ehinmowo, 2009), Mutagenicity, loss of hearing, Nepropathy (Gentamycin, Neomycin), Hepatotoxicity (Nisha, 2008). Other effects include reproductive disorders (Sundlof, 1994; Czeize *et al*., 1998; Doyle, 2006), bone marrow toxicity (Chloramphenicol) and Anaphylactic reaction in individuals with known hypersensitivity to penicillin (Dipeolu, 2004; Gomes and Demoly, 2005; Doyle, 2006; Shareef *et al*., 2009). Antibiotic residues in foods of animal products can lead to losses in the food industry through international trade (Javadi *et al*., 2009). This is why poultry products (meat or eggs) from developing countries like Nigeria could not find exportation market overseas. However, it has been demonstrated that most veterinary drugs have varying degree of stability during cooking and that cooking influences the level of risk posed by drug residues (Javadi *et al*., 2009). In Nigeria, most of the food producing animal products are always cooked, fried or roasted before consumption. Although, it was reported by Dipeolu (2004) that residues of some antibiotics tends to persist in poultry meat and eggs following common/conventional cooking methods, more findings about the effects of cooking on antibiotic residues are needed to accurately determine the risk of consumer exposure to these drugs in Nigeria.

Prevention of antibiotic residues in edible poultry tissues: The issue of prevention of antibiotic residues in food of animal origin is of paramount importance for those veterinarians employed in pharmaceutical and regulatory sectors responsible for assessing the fate of drugs and chemicals that enter the human food chain via the edible animal products (like meat, eggs or milk) (Muhammed *et al*., 2009). The first step in antibiotic residues prevention in edible tissues is to make individuals and organization aware of the problem through education by veterinary personal organization, literatures and governmental agencies (Muhammed *et al*., 2009). In many countries of the world, whenever an animal is slaughtered or its edible products are collected, there is a legal requirement that veterinary drug concentration in these products are not at level greater than the maximum residue level or tolerance established as safe by the relevant regulatory authority in the country of origin (Muhammed *et al*., 2009). Drug withdrawal time is defined as the time required for drug residues to reach a safe concentration in the edible tissues of animals for human consumption (Booth, 1982; Alhendi *et al*., 2000). Also veterinarians should avoid irrational use of antibiotics in field practice (Nisha, 2008; Policy Guide, 2009). Rapid screening procedures are required for the analysis of antibiotic residues, instant grading and prohibition of foods of animal origins that contain antibiotics more than MRL (Nisha, 2008). Moreover, processing of milk, proper cooking, roasting or frying of eggs, poultry meat and other tissues help in the inactivation of antibiotics (Nisha, 2008; Javadi *et al*., 2009). Refrigeration also causes disappearance of penicillin and through pasteurization, most of antibiotics losses activity. The use of activated charcoal, resin and UV irradiation also helps in lowering the level of antibiotic residues in animal tissues (Nisha, 2008).

Measures for control of antibiotic residues in poultry edible tissues: Harmful antibiotic residues can

be avoided through the proper use of antibiotics. This is because, the presence in food of residues of a new veterinary drug above threshold level causes the food to be adulterated under section 402 (a) 2 (D) of the act (Policy Guide, 2009). The ability of individuals who produce and sell food producing animals and animal products such as meat, eggs and milk to have systems to monitor and control the use of veterinary drugs is an indispensable adjunct to providing appropriate therapy and is essential to avoiding illegal residues (Policy Guide, 2009). Persons involved in raising, handling, transporting, holding and marketing food producing animals are encouraged to establish systems to ensure that veterinary drugs are used properly and to prevent potentially hazardous drug residues in edible animal products. These control systems should include the following:

- Identifying and tracking animals to which drugs were administered, in order to preclude the sale of edible animal tissues (meat, milk or eggs) containing illegal residues (identification may be by specific animal identification, pen, Quarantine, segregation or other means).
- Maintaining a system of medication and or treatment records that at aminimum, identifies the animal (s) treated (individual animals, pens, etc.), the date (s) of treatment, the drug (s) administered, who administered the drug (s), the amount administered and the withdrawal time prior to slaughter (and when meat, eggs, milk etc. can be used, if appropriate).
- Properly storing, labeling and accounting of all the drug products and medicated feeds.
- Obtaining and using veterinary prescription drugs only through a licensed Veterinarian based on a valid veterinarian/client/patient relationship and
- Educating all employee and family members involved in treating, hauling and selling the animals on proper administration techniques, observance of withdrawal times and methods to avoid marketing adulterated animal tissues and products destined for human consumption.

Establishing and maintaining such systems should help producers avoid marketing meat, eggs, milk or other edible animal tissues containing illegal residues and avoid regulatory action based on sections 402(a) 2 (D), 402(a) 4, or 501(a) 5 (Policy Guide, 2009). Person who do not administer medication but who purchase or lease animals for milking or sale for slaughter (such as livestock dealers) should also establish and implement a record keeping system. This system should include information on the source of the animals and whether the animal has been medicated (when, with what drug and the withdrawal period) to preclude marketing of edible tissues (meat, eggs or milk) that contain illegal residues. Such person may also be subjected to regulatory action, if they market animal edible tissues containing illegal residues and failed to take reasonable precautions to prevent the sale of these adulterated food of animal origin (Policy Guide, 2009). Moreover, veterinary and pharmacokinetic programmes at various universities or private research facilities should also provide researches to support and complement the Federal monitoring effort (Donoghue, 2003). This collaboration will produce pharmacokinetic models for antibiotics and other chemicals transfer and deposition in poultry tissues (Donoghue, 2001, 2003) and also analytical methods for the detection of antibiotics (e.g., ampicillin, tetracycline sulfonamides etc.) and pesticides (e.g., organochlorine, organophosphorus etc.) in poultry tissues (Lehotay *et al*., 2001; Heller *et al*., 2002; Donoghue, 2003).

CONCLUSION

Many people in Nigeria especially those in remote areas are still not aware that edible poultry products especially eggs (yolk or albumen) can contain toxic level of antibiotic residues and most likely when these tissues are disposed soon after medication of the birds with antibiotics; and that the public health hazards resulting from consumption of these products can be life threatening. In Nigeria, some researchers have worked together as a team to analyse samples of meat from cattle, pigs, fish, poultry and other animal products such as eggs and milk for antibiotic residues (Alonge, 2001; Dipeolu and Alonge, 2002; Kabir *et al*., 2004; Dipeolu, 2004; Geidam *et al*., 2009; Olatoye and Ehinmowo, 2009). Even though samples were collected from open markets, farms and abattoirs, they have recorded residues of tetracycline, streptomycin, penicillin and chloramphenicol in analytes. However, there are recently more antibiotics used in livestock production especially poultry production in Nigeria. In this perspective, a large populace of Nigeria is at high risk of consuming edible poultry tissues with antibiotic residues, most especially those in urban areas where exotic breeds of chicken meat and eggs are bred and sold in hotels, foreign restaurants (e.g., Mr. Biggs), tea cafe, ice cream cafe, roasted chicken spots etc. Infact, there have been scanty reports on various veterinary drug residues in edible poultry tissues and the extent of the public health hazards they cause in Nigeria. Similarly, there is no specific residue monitoring programme in Nigeria (Geidam *et al*., 2009). This may be due to the fact that the analytical techniques are expensive and are not readily available in Nigeria. Yet, more researches need to be conducted on other antibiotic residues detection in edible poultry tissues like meat and eggs in Nigeria.

RECOMMENDATION

There is need for public awareness through media or campaign programme to educate the less privileged

populace of the risk of consuming poultry products with illegal levels of antibiotic residues. Therefore, the WHO and Federal Government agency controlling food and drugs (NAFDAC/FAO) should provide extensive regulatory oversight to ensure the safety of our food supply. This should include mandatory and rigorous safety studies (toxicology and pharmacokinetics) before any antibiotic can be approved for use in poultry industry. There is also need to monitor the supply of poultry edible products especially those imported into the country during festivals. The Federal and State Government authorities of Nigeria should mandate a legislation regarding drug use and veterinary drug residue control. They should also provide some basic facilities for nationwide specific residue monitoring programme and periodic surveillance of antibiotic residues in edible tissues at the level of abattoir, farms, market, etc. The Federal Government of Nigeria need to support universities, research institutes and private researchers financially in order to encourage and promote the gathering of reports on veterinary drug residues and the extent of residue problems in all parts of Nigeria. Therefore, they should fund veterinary research institutes to investigate contaminant transfer into poultry tissues (meat and eggs) through the following approaches:

- Use of traditional feeding studies to investigate transfer of individual drugs into edible poultry tissues
- Development of models to predict the pattern of contaminant transfer for a number of different chemical compounds and
- Collaborative efforts to develop methods to identify if and when contaminant transfer is taking place. Therefore, it is expected that when these suggestions are implemented, the occurrence of antibiotic residues in edible poultry tissues and products will be corrected to a greater extent in Nigeria

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