

Full Length Research Paper

Effect of roasting, boiling and microwaving cooking method on Doxycycline residues in edible tissues of poultry by microbial method

Javadi A.

Food Hygiene Department, Veterinary Science Faculty, Tabriz Branch, Islamic Azad University, Tabriz, Iran, 5157944533. E-mail: Javadi@iaut.ac.ir. Tel: +0914-116-5059.

Accepted 21 October, 2016

The purpose of this study was to determine the effects of different cooking processes like boiling, roasting and microwaving on Doxycycline residues in chicken muscle, liver and gizzard tissues of broiler chickens. Each chick was fed by water and food with 0.1% of Doxycycline in their drinking water for 5 consecutive days. Then, three locations were sampled aseptically from each carcass: Breast muscle, liver and gizzard. Doxycycline residue was analysed using microbial inhibition method by plates seeded with *Escherichia coli*. After doing different phases of the test on raw samples, the positive raw samples were cooked by various cooking procedures and we surveyed the cooked samples with a similar method again for the detection of residue. The results showed a reduction in the concentration of Doxycycline residue after different cooking processes and a part of the residue in the boiling process were excreted from the tissue to the cooking fluid. Between the various agents affecting antibiotics residue after the cooking process, cooking time and temperature can play a major role in antibiotic residue reduction while cooking food. Regarding the results of this study, we can conclude that cooking processes do not guarantee a full elimination of these drugs present in condemned animals and it can only decrease its amounts.

Key words: Cooking, Doxycycline, residue, poultry, edible, tissue.

INTRODUCTION

Tetracycline antibiotics (TCAs) have a broad range of activity against variety of Gram -positive and Gram-negative bacteria and have low cost. For these reasons, TCAs are widely used in veterinary medicine for preventing and treating several diseases and for promoting growth in cattle and poultry (Bogialli and Di, 2009). Furthermore, they are easy to administer and are effective through oral dosing via water and feed.

Tetracycline (TC), oxytetracycline (OTC), chlortetracycline (CTC) and doxycycline (DOX) are four members of this antibiotic group. In recent years, the abundant and in some cases improper use of TCs has resulted in the presence of residues in edible animal tissues, which has harmful effects on consumer's health, such as allergic reactions, liver damage, yellowing of teeth and gastrointestinal disturbance (Debuf, 1998; Joint FAO/WHO Expert Committee on Food Additives, 2002; Jing et al., 2009). Doxycycline (DOX) is a broad-spectrum antibiotic from tetracycline group that is widely used

in the treatment of respiratory tract infections and infectious diseases caused by "rickettsiae", "mycoplasmas" and "Chlamydia" in various species (Hardman et al., 2001; Kirbiš, 2006). The detection of antibacterial residues in food requires screening methods sensitive at antibiotic concentrations close to the maximum residue limit (MRL). The European union (EU) legislation on veterinary drug residues established in 1997, provisional maximum residue limits (MRL) for DOX in bovine, porcine and poultry at 600 µg kg⁻¹ in kidney, 300 µg kg⁻¹ in liver, skin and fat and 100 µg kg⁻¹ in muscle (Croubels et al., 1998; Fuselier et al., 1999).

An efficient screening method for the detection of antibacterial residues in food needs to be low-cost and high-throughput, able to effectively identify potential noncompliant samples from a large set of negative samples. Microbial inhibitions assays were the earliest methods used for the detection of antibiotic residues and they are still widely used. They are very cost-effective

and in contrast to, for example, immunological or receptor-based tests and allow detection of a wide spectrum of antibiotics (Aerts et al., 1995; Haasnoot et al., 1999; Pikkemaat, 2009). Their other advantages are the option to analyze a large number of samples simultaneously and the relatively short time needed for preparation of samples as no purification procedures are required. A positive result should be confirmed with chemical or physical methods (Ferrini et al., 2006; Kirbiš, 2006). A plate test consists of a layer of inoculated nutrient agar, with samples applied on top of the layer, or in wells in the agar. Bacterial growth will turn the agar into an opaque layer, which yields a clear growth-inhibited area around the sample if it contains antimicrobial substances. In Europe this has been the main test format since screening of slaughter animals for the presence of antibiotics started (Pikkemaat, 2009). On the basis of other researches, the plate seeded with *Bacillus subtilis* is suitable for detection of tetracycline residues (Kirbiš, 2006; Chang et al., 2000). Between 1995 and 1999, Rose et al. (1995, 1999) demonstrated that residues of a range of veterinary drugs have varying degrees of stability during cooking and therefore, the cooking influences the level of risk posed by such residues (Rose et al., 1999).

Since the most of foods-producing animals are always cooked before consumption and the variations in doxycycline levels in the tissue are dependant on type of cooking, more findings about the effect of cooking on doxycycline residue are needed to accurately determine consumer exposure to this drug.

MATERIALS AND METHODS

Chickens and drug administration

Sixty broiler chickens (aged 20 days) were randomly divided into 2 groups; control group and case group; each containing 30 chicks in order to remove any probable antibiotic residues from chicken's body; they were fed by feed and water free of antibiotics for around 10 days. Each of chicks in case groups were fed by water and feed with 0.1% of doxycycline in their drinking water for 5 consecutive days and chicks in control group were fed by similar water and feed but without doxycycline for similar period.

Preparation of samples

After the 5th day of the drug administration, chickens were slaughtered and breast muscles; livers and gizzards were sampled aseptically from each carcass. After notation of samples characteristics; they were placed in sterile polyethylene containers.

Cooking operation

Boiling

A 20 g sample was placed into a strainer, immersed in 10 ml of water bath preheated to 100°C and cooked for the specified time (9 min for liver samples; 24 min for muscle samples and 85 min for gizzard samples), removed and allowed to cool.

Roasting

A 20 g sample was placed on a metal baking tray and cooked well in an electric oven (Memmert, Germany) at 200°C for the specified time of 25, 40 and 60 min for liver, muscle and gizzard samples, respectively, after which it was removed and allowed to cool. No juice, which drained from the samples as they were cooked, was collected. The cooked muscle had a "well cooked" appearance.

Microwaving

A 20 g sample was placed on a turned table. The sample was cooked under full power (900 W) for the specified time (3 min for all samples), removed and allowed to cool. No juice was collected.

Test procedure for raw and cooked samples

Test organism used in this study were *Bacillus subtilis* (PTCC 1365) and the used agar "medium" was Muller Hinton agar (Quelab, England) and the pH of the this medium were adjusted to pH = 6 with sodium hydroxide and acid acidic and autoclaved as indicated by the manufacturers. Sterile Petri dishes (diameter 90 mm) were filled with 25 ml of the prepared culture medium then we seeded *B. subtilis* in plates. Raw samples disks (diameter 2 mm) were put on each plates also we put a paper disk as negative control. A positive raw sample is indicated by a complete inhibition of growth in an annular zone not less than 2 mm wide around the disc. Less than 2 mm of inhibitory zone indicated negative result (Myllyniemi, 2001). Results of inhibition zones diameter was read by digital caliper. The positive raw samples were selected for cooking processes (boiling; roasting and microwaving) then we performed the test for cooked samples just like raw samples after complete cooking of them. Also, we placed 0.01 ml of boiling fluid on plates after boiling process of samples. After all samples were put onto the plates, plates were incubated at 37°C for 24 h.

Analytical method

Comparison between the mean diameter of inhibition zones around raw and cooked samples analyzed by ANOVA test and SPSS software version 15.

RESULTS

Comparison of the effects of different cooking methods on the mean diameter of inhibition zones (mean±SE) around raw and cooked samples are showed in Table 1. We see that all cooking processes can lead to a reduction ($p < 0.01$) in diameter of inhibition zones in cooked samples rather than raw samples.

DISCUSSION

The microbiological screening tests are essentially qualitative screening test, which detects any tissues substance with the property of bacterial inhibition. The advantages of these tests are quite simplicity, inexpensiveness, sensitivity, reliability, and they do not need for high skill of operator. They also have the

Table 1. Comparison of mean inhibition zones diameter (mean±SE) between raw and cooked samples in different cooking procedures.

	Muscle	Liver	Gizzard
Raw	12.3 ±0.47 ^d	11.3± 1.49 ^c	8.4 ± 2.24 ^b
Boiled	8 ± 0.42 ^c	0.0 ±0.0 ^a	0.0 ±0.0 ^a
Boiling fluid	6.6 ±1.37 ^c	0.0 ±0.0 ^a	0.8 ± 0.8 ^a
Micro waved	0.0 ±0.0 ^a	0.0 ±0.0 ^a	3.14 ±1.03 ^a
Roasted	3.1 ± 0.69 ^d	3.9 ±0.46 ^d	1.3 ± 0.8 ^d

a, b, c and d: Differences between the means that have common letters are significant (p<0.01).

advantage of being multi-residue tests because inhibition is caused by a wide range of antibiotics. In the microbial test, observation of inhibition zones is possible when antibiotics residue is above MRL because this test can't detect amounts of residues below or around allowable amounts. According to the results of our study, maximum mean inhibitory zone in cooked muscle samples related to boiling process and minimum mean inhibitory zone regarded to microwaving method. Thus, the most reduction of doxycycline residues in cooked muscle samples related to microwaving process and we found the highest detectable amount of the residue in boiling process and boiling fluid of cooked muscle. A part of residue excreted from tissue to cooking fluid in boiling process about muscle and gizzard samples. The roasting process has the least effect on the reduction of doxycycline residue in liver samples and we didn't see any inhibitory zones around cooked liver samples about other cooking methods. Boiling process about gizzard tissue was led to the minimum mean inhibitory zone around cooked gizzard samples and maximum mean inhibitory zone related to microwaving process. Thus, the most reduction of doxycycline residues in cooked gizzard samples related to boiling process (Table 1).

The difference between mean inhibitory zone of raw and cooked samples in various cooking processes were not significant (p<0.01); also, the differences between various cooking methods were not significant about muscle tissue while it was significant about gizzard samples (p<0.01). The difference between boiling process and microwaving method was significant about liver samples (p<0.01) (Table 1). The results of our study are consistent with other studies on the fate of doxycycline residue. Based on a research about the effect of cooking processes on tetracycline compounds in poultry products in the eastern province of Saudi Arabia, the authors mentioned that the MRL for doxycycline was exceeded in raw liver samples in 3 poultry farms. However, after cooking (100°C for 20 min) the mean detectable concentrations of this drug were decreased to below MRL. Mean concentrations of doxycycline were also above the MRL in raw muscle obtained from 5 farms. However, after cooking (100°C for 20 min), the MRL of these drug was exceeded only in 2 of the farms (Al-Ghamdi et al., 2000). According to a study on the

stability of antibiotics in a pork meat-kidney-liver mixture after the sterilization step (134°C for 20 min), it was proved that doxycycline was degraded (less than 10% remaining activity) after the sterilization step (Van egmond et al., 2000) or in a study on Thermostability of doxycycline at ultrahigh temperatures. Whereas low-temperature-long-time treatments (conventional sterilization) would destroy >98% of the initial concentration of the residues of the doxycycline, high-temperature-short-time treatments (UHT) would leave unaltered doxycycline in the 50 to 90% range (Hassani et al., 2008). The results of these researches confirm the findings of our study about the decrease of doxycyclin activity after cooking procedure.

According to the results of this paper and findings of another researches about effects of different cooking procedures on antibiotic residue in food stuff, we can concluded that cooking processes don't guarantee a full break-down of these drug present in condemned animals and it can only decrease it's amounts and a part of residue in boiling process excreted from tissue to cooking fluid in boiling process. Thus, exposure to residues may be reduced by discarding any juices which come from the edible tissues as they are cooked. Between the various agents affecting antibiotics residue after cooking process, cooking time and temperature can play major role about antibiotic residue reduction while cooking food. Also, additional separately residue detection experiments on the metabolites of these drugs must be done that can be produced after cooking and toxicology experiments must be performed for detection of their effects of them on human bodies.

ACKNOWLEDGMENT

We acknowledge the vice chancellor in research affairs of Tabriz Islamic Azad University for funding of our research and from the microbiology laboratory of veterinary faculty of Tabriz Islamic Azad University for their helps.

REFERENCES

Aerts MML, Hogenboom AC, Brinkman UA (1995). Analytical strategies for the screening of veterinary drugs and their residues in edible

- products. *J. Chromatogr. B. Biomed. Sci. Appl.*, 667(1): 1-40. Al-Ghamdi MS, Al-Mustafa ZH, El-Morsy F, Al-Faky A, Haidr I, Essa H (2000). Residues of tetracycline compounds in poultry products in the eastern province of Saudi Arabia. *Public Health*, 114: 300-304.
- Bogialli S, Di Corcia A (2009). Recent applications of liquid chromatography–mass spectrometry to residue analysis of antimicrobials in food of animal origin, *Anal. Bioanal. Chem.*, 395: 947–966.
- Chang CS, Tai TF, Li HP (2000). Evaluating the applicability of the modified four-plate test on the determination of antimicrobial agent residues in pork. *J. Food Drug Anal.*, 8(1): 25-34.
- Croubels S, Baert K, De Busser J, De Backer P (1998). Residue study of doxycycline and 4-epidoxycycline in pigs medicated via drinking water, *Analyst*, 123: 2733–2736.
- Debuf Y (1998). *The veterinary formulary*. Pharm. London, p. 97.
- Ferrini AM, Mannoni V, Aureli P (2006). Combined plate microbial assay (CPMA): A 6 – plate method for simultaneous first and second level screening of antibacterial residues in meat. *Food Addict. Contam.*, 23(1): 16-24.
- Fuselier R, Cadieu N, Maris P (1999). S.T.A.R.: screening test for antibiotic residues in muscle results of a European collaborative study, A.F.S.S.A. community reference laboratory for residues of veterinary drugs, France.
- Hardman JG, Limbird LE, Gilman AG (2001). *Goodman and Gilman's the Pharmacological Basis of Therapeutics*, 10th edition McGraw-Hill, New York.
- Haasnoot W, Stouten P, Cazemier G, Lommen A, Nouws FM, Keukens HJ (1999). Immunochemical detection of aminoglycosides in milk and kidney, *Analyst*, 124: 301-305.
- Hassani M, Lazaro R, Perez C, Condon S, Pagan R (2008). Thermostability of oxytetracycline, tetracycline, and doxycycline at ultrahigh temperatures, *J. Agric. Food Chem.*, 56(8): 2676-2680
- Jing T, Gao XD, Wang P, Wang Y, Lin YF, Hu XZ, Hao QL, Zhou YK, Mei SR (2009). Determination of trace tetracycline antibiotics in foodstuffs by liquid chromatography–tandem mass spectrometry coupled with selective molecular-imprinted Solid-phase extraction, *Anal. Bioanal. Chem.*, 393: 2009–2018
- Joint FAO/WHO Expert Committee on Food Additives (2002). Evaluation of certain veterinary drug residues in food: fifty eighth report of the Joint FAO/WHO Expert Committee on Food Additives, WHO technical report series, No. 911. FAO, Rome, p. 33
- Kirbiš A (2006). Microbiological 5-plate screening method for detection of tetracyclines, aminoglycosides, cephalosporines and macrolides in milk, *Slovenian Vet. Res.*, 43(4): 161-8
- Myllyniemi AL, Nuotio L, Lindfors E, Rannikko R, Niemi A, Backman C (2001). A microbiological six-plate method for identification of certain antibiotic groups in incurred kidney and muscle samples. *Analyst*, 126: 641-646
- Pikkemaat MG (2009). Microbial screening methods for detection of antibiotic residues in slaughter animals, *Anal. Bioanal. Chem.*, 395: 877–891
- Rose MD, Bygrave J, Sharman M (1999). Effect of cooking on veterinary drug residues in food part 9: Nitroimidazoles. *Analyst*, 124: 289–294
- Van Egmond HJ, Nouws JFM, Schilt R, Van Lankveld-Driessen WDM, Streutjens-van Neer EPM, Simons FGH (2000). Stability of antibiotics in meat during a stimulated high temperature destruction process, The Euro Residue conference IV, May 08 - 10, Veldhoven, Netherlands, pp. 430-438