

Effects of graded levels of Tetracin® on physico-chemical and sensory properties of broiler meat

¹*Akinwumi, A. O., ¹Odunsi, A. A., ²Omojola, A. B., ³Olatoye, I. O., ⁴Akande, T. O. and ¹Olawuyi, B. S.

¹Animal Products and Processing Unit, Department of Animal Nutrition and Biotechnology, Ladoké Akintola University of Technology, Ogbomosho, Oyo State, Nigeria.

²Meat Science Laboratory, Department Animal Science, University of Ibadan, Ibadan, Oyo State, Nigeria.

³Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, Nigeria.



⁴Department of Animal Science, Obafemi Awolowo University, Ife, Osun State, Nigeria.

*Corresponding author: aoakinwumi@lautech.edu.ng; yimika2akin@yahoo.com;

Abstract

+2348029455394

Tetracin® (a feed grade veterinary antibiotic) was administered at 0, 50, 100, 150 and 200mg/kg to conventional starter and finisher feed for broilers for a period of six weeks before the breast meat were analyzed for physical, chemical and organoleptic properties. One hundred and fifty (2 weeks old) broiler chicks were randomly divided into 10 birds per replicate with 3 replicates per treatment. At the end of the feeding trial, 6 birds per treatment were slaughtered, defeathered, eviscerated and dressed. The breasts cuts were however subjected to laboratory analyses. No statistically significant ($P>0.05$) differences were observed in drip loss, chilling loss, shear force, ash and moisture contents of broiler meat across the treatment groups. However, the cooking loss and thermal loss progressively increased ($P<0.05$) with the corresponding increase in Tetracin®. Similarly, WHC was also significantly ($P<0.05$) influenced with increased inclusion of Tetracin®. Crude protein increased ($P<0.05$) but ether extract was reduced with inclusion of Tetracin®. Meat without antibiotics was highly rated ($P<0.05$) for flavour, juiciness and tenderness while colour and general acceptability were not significantly ($P>0.05$) influenced with or without Tetracin®. Conclusively, the inclusion of Tetracin® improved the chemical properties of broiler meat but the physical properties (cooking loss and WHC), flavour, juiciness and tenderness of the meat were compromised especially when administered above 100mg/kg feed.

Keywords: Tetracin®; antibiotics; Physical; chemical; sensory properties; broilers

Introduction

Antibiotics are among the most widely used veterinary drugs in poultry industry (Simon and Baxter, 2006). They are used for poultry birds not only to treat (Olatoye and Ehinmowo, 2009),

and protect (Nisha, 2008) the birds from different diseases, but also to promote growth of the birds (Geidam *et al.*, 2009), to improve feed conversion ratio (FCR), to increase weight gain and to maximize economic returns from the

Effects of Graded levels of Tetracin® on Quality and Sensory Attributes of Broiler Meat

individual bird (Aamer *et al.*, 2000; Costa *et al.*, 2007; Akinwumi *et al.*, 2013a). The use of antibiotics has facilitated the efficient production of poultry allowing the consumers to purchase at reasonable cost, high quality meat and eggs (Donoghue, 2003). Despite these benefits ascribed to the use of antibiotics, there is a negative side to its use.

Aamer *et al.* (2000) and Akinwumi *et al.* (2013a) reported that abuse of antibiotic occurs when they are: used unnecessarily, over prescribed, employed in wrong combination, changed quickly over to other drugs, used persistently, given in inadequate dosage, given through self medication, used for preventive purposes, and used unauthorized. Due to the above-mentioned practices, antibiotic residues accumulate in various body tissues like muscles, liver and kidney and eggs of birds (Akinwumi *et al.*, 2013a).

There are environmental and human health risks that are associated with these residues which ranged from direct to indirect toxicity on consumers exhibiting allergic reactions to indirect problems through the generation of resistant strains of pathogenic bacteria and the residual contamination of manures used in crop production (Dubois *et al.*, 2001). To ensure consumer safety worldwide, regulatory authorities have set MRL's (Maximum Residual Limit) for several veterinary drugs (Zeina *et al.*, 2013). These MRL's are expected to regulate the maximum permitted levels of the drug residue for each antibiotic that is considered safely

acceptable in food of animal origin (Akinwumi *et al.*, 2013a). Hughes and Heritage (2004) reported other beneficial effects of antibiotics on product quality, such as decreased fat, increased meat protein Δ as well as indirect benefits such as a reduction in the amount and cost of feed needed which consequently results in profit maximization. Since continuous administration of antibiotics at sub-therapeutic regime has been documented to influence the protein and fat content of meat, other meat quality properties may also be influenced by the administration of antibiotics. This study was therefore aimed at determining the effect of a feed-grade antibiotic (Tetracin®) on physico-chemical and sensory properties of broiler meat.

Materials and methods

A six week experiment was conducted with one hundred and fifty (150) 2 week old (Anak strain) broiler chicks that were randomly assigned to 5 experimental treatments (3 replicates of 10 birds each) representing 5 levels of veterinary antibiotic Tetracin®. Tetracin® is a tetracycline based antibiotics bought at a local veterinary store in Ogbomoso and was administered at 0, 50, 100, 150 and 200mg/kg of feed to represent T1 (control), T2, T3, T4 and T5 respectively. At the expiration of the feeding trial, six (6) birds per treatment were slaughtered. Selected birds were fasted for 8 hours prior to slaughter, and bled for 90seconds from a single cut that severed the carotid artery and jugular vein. After

bleeding, birds were scalded, defeathered and eviscerated and dressed as described by Abdullah *et al.* (2010). The breast meat was however subjected to physico-chemical and sensory analyses with their methodologies as follow;

Water Holding Capacity

Water holding capacity (WHC) of the samples was determined by the filter press method as modified by Suzuki *et al.*, (1991). Intact meat samples from the primal cuts were weighed, placed between equal sized filter papers (10.1x10.1cm²) and pressed between two plexi- glasses using a vice for one minute. The meat samples were removed and oven dried at 105°C for 24 hours to determine the moisture content. The amount of water released from the sample was measured as the area of the filter paper wetted by pressing, relative to the area of pressed sample using a compensatory plani-meter. Thus water holding capacity was calculated as follows:

$$WHC = \frac{100 - (Ar - Am) \times 9.49}{Wm \times Mo} \times \frac{100}{1}$$

Where,

Ar = Area of water released from meat (cm²)

Am = Area of meat sample (cm²),

Wm = weight of meat sample (mg)

Mo = Moisture content of the meat (%),

and

'9.49' is a constant.

Cooking Loss

This was determined according to the procedure by Honikel (1998) and Malgorzata *et al.* (2005). The samples were wrapped individually in heat

resistant polythene bags and immersed in water inside a water bath at a temperature of 80°C for 20 minutes. After cooking, the meat samples were allowed to equilibrate to room temperature. The meat samples were reweighed and cooking loss was calculated as the percentage change in weight after cooking.

Thermal Shortening

The length of the meat was measured and placed in a heat resistant polythene bag immersed in already boiling water and allowed to cook for 20 minutes using water bath at 80°C. The length of each sample was recorded after cooking. The percent change in length of meat was taken as the thermal loss (Honikel, 1998; Malgorzata *et al.*, 2005).

Chilling Loss

Meat samples were chilled for 24 hours according to the method of King *et al.*, (2003). The chilling loss was determined as difference between the warm carcass weight and chilled weight expressed as percent of warm carcass weight as described by Awosanya and Okubanjo (1993).

Cold Shortening

This was determined by measuring the length of meat before and after chilling (King *et al.*, 2003). The percentage change in the length of meat was referred to the cold shortening.

Shear force

Weighed meat samples (approx 10g) were wrapped in a thermo-resistant polyethylene bags and cooked in a pre-heated pressure cooking pot for 20 minutes to an internal temperature of

80°C (Malgorzata *et al.*, 2005). The meat samples were removed and allowed to equilibrate to room temperature (27°C) before removing 1.25cm diameter cores parallel to muscle fibre orientation with a coring device (Qiaofen and Da-Wen, 2005). They were shared at three locations with Warner-Bratzler V-notch blade shearing instrument. Shear force determined in this way expressed the tenderness of the meat after cooking.

Proximate composition

The proximate analysis of meat samples was done by the method described by AOAC (2000) to get the moisture content, crude protein, ether extract and ash.

Organoleptic Properties

This was conducted using a 10 member semi-trained panelists according to the procedures of AMSA (1995). Meat preparation was done using a wet cooking method. The samples were wrapped in impervious polythene pouches which could not be destroyed by cooking process. In the process, the meat samples were cooked in boiling water for 20 minutes using water bath with no spices added to the meat. The meat was then served to 10 member taste panels drawn from students and staff in the Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology, Ogbomoso. The trained panelists evaluated the samples for colour, flavour, juiciness, tenderness and general acceptability. The assessment was based on a 9 point hedonic scale. The score was arranged in a descending

order, the maximum score 9 was given to extremely like condition while the lowest score 1 was for the poorest condition.

Statistical analysis

All data obtained were processed and subjected to analysis of variance (ANOVA) using statistical analysis software (SAS, 1999). Significantly different means were separated using Duncan's multiple Range (DMR) test.

Results

The effect of inclusion of graded levels of Tetracin® on the physical properties of broiler chicken is presented in Table 1. The thermal and cooking losses and WHC were influenced ($P<0.05$) with the increasing levels of the antibiotics. The values for both thermal and cooking losses increased ($P<0.05$) progressively with the corresponding increase in the inclusion level of Tetracin® while a reverse ($P<0.05$) trend was observed in WHC. Drip loss, chilling loss and shear force were not significantly ($P<0.05$) different across the treatment groups. The means obtained however ranged from 3.40 - 3.70% in the drip loss, 5.32 - 3.70% for chilling loss and 2.01 - 2.34kg for shear force.

The inclusion of Tetracin® significantly ($P<0.05$) influenced both the crude protein and ether extract in an opposite direction. The CP progressively ($P<0.05$) increased with the increase in the inclusion levels. However, no significance was obtained from the ash content and the moisture content of the broilers chicken. The values ranged

Table 1: Effect of graded levels of Tetracin® on physical properties of broiler meat

Parameter (%)	T1 (0mg/kg)	T2 (50mg/kg)	T3 (100mg/kg)	T4 (150mg/kg)	T5 (200mg/kg)	SEM
Thermal loss	10.13 ^b	10.28 ^b	10.47 ^b	10.39 ^b	13.21 ^a	0.23
Cooking loss	18.27 ^d	16.20 ^c	21.35 ^c	23.23 ^b	27.88 ^a	1.21
WHC	81.62 ^a	83.00 ^a	77.54 ^{ab}	76.80 ^{ab}	71.98 ^b	2.03
Drip loss	3.42	3.54	3.40	3.70	3.63	0.07
Chilling loss	5.45	5.38	5.48	5.32	5.59	0.15
Shear force	2.01	2.29	2.34	2.33	2.10	0.04

^{a,b,c}: Means along the same row with different superscripts differ significantly (P<0.05)

Table 2: Effect of graded levels of Tetracin® on chemical properties of broiler meat

Parameter	T1 (0mg/kg)	T2 (50mg/kg)	T3 (100mg/kg)	T4 (150mg/kg)	T5 (200mg/kg)	SEM
Crude protein	17.66 ^c	18.34 ^b	20.66 ^a	21.12 ^a	21.23 ^a	2.11
Ether Extract	8.02 ^a	7.31 ^{ab}	6.02 ^b	5.11 ^b	5.24 ^b	0.21
Ash	1.02	1.05	1.02	1.17	1.17	0.05
Moisture contents	70.83	70.94	69.81	70.16	69.99	0.53

^{a,b,c}: Means along the same row with different superscripts differ significantly (P<0.05)

from 1.02 – 1.17% and 69.81 – 70.94% for ash content and moisture content. The results of the evaluation panel for the main effect of the inclusion levels of Tetracin® on the broiler chicken are shown in Table 3. The colour ratings were not significantly different (P>0.05) from each other with or without the antibiotic. The panelists gave the highest (P<0.05) flavor,

juiciness and tenderness ratings to the meat from the control diet (T1 0mg/kg) while the least value was found in T5. For both eating quality parameters (flavour and tenderness), the rating for broiler meat from T2, T3 and T4 were similar (P>0.05). No significant difference was however observed in the rating of the general acceptability of the chicken samples.

Table 3: Effect of graded levels of Tetracin® on sensory properties of broiler meat

Parameter	T1 (0mg/kg)	T2 (50mg/kg)	T3 (100mg/kg)	T4 (150mg/kg)	T5 (200mg/kg)	SEM
Colour	6.56	6.22	6.20	6.51	6.20	0.24
Flavour	5.75 ^a	5.28 ^{ab}	5.30 ^{ab}	5.39 ^{ab}	4.80 ^b	0.17
Juiciness	7.38 ^a	6.90 ^{ab}	6.80 ^{ab}	6.87 ^{ab}	5.67 ^b	0.20
Tenderness	6.49 ^a	6.39 ^a	6.40 ^a	5.63 ^{ab}	4.45 ^b	0.31
General Acceptability	7.42	7.30	7.28	7.30	7.31	0.34

^{a,b,c}: Means along the same row with different superscripts differ significantly (P<0.05)

Discussion

The higher cooking loss found with the inclusion of the feed grade antibiotics was similar to the work of Costa *et al.* (2007) using sub-therapeutic tylosin. In

poultry, the muscle fiber increases with age and fast-growing chickens have larger fiber diameter than slow-growing ones (Klosowska *et al.*, 1993; Dransfield and Sosnicki, 1999) It has

also been confirmed that muscle meat composed of large fibre diameter is less cohesive and has a lesser compact structure than meat with smaller fibres (Dransfield and Sosnicki, 1999; Akinwumi *et al.*, 2012). It is also reasonable to assume that this large-fibre meat will have a lower water-holding capacity, given that the space within and between its myofibrils will be bigger (Costa *et al.*, 2007). This has proven why more cooking loss was reported with the antibiotic supplemented chickens that grew faster than the control.

Fakolade (2007) stated that cooking loss depends on raw meat qualities and is of interest because it is expected to explain part of the variation of juiciness. It is also of great economic importance because higher cooking loss gives an expectation of loss. Similar reason was responsible for the lower WHC reported since both cooking loss and WHC were inversely proportional to each other which were clearly shown with the results. Lower WHC indicates losses in the nutritive value through exudates that are released and result in drier and tougher meat (Dabes, 2001; Akinwumi *et al.*, 2013b). The report is in line with those of Latif *et al.* (1998) and Berri *et al.* (2005) who earlier reported lower WHC values in fast growing bird to the slow growing ones.

In addition to the loss of saleable weight, purge loss also entails the loss of a significant amount of protein (Offer and Knight, 1988). With the high losses reported with the meat with antibiotics residues in this study, the nutritive

values of such meat would have been lost.

This study revealed that the inclusion of the feed grade antibiotics had no effect on the shear force, drip loss and the chilling loss. The result for the drip loss was similar to the finding of Costa *et al.* (2007) in a similar study but the shear force was significantly influenced. They however stated that since the primary factors of production (breed, age, and nutritional status), pre-slaughtering and slaughtering conditions and subsequent storage (Honickel, 1998; Berri, 2000; Fletcher, 2002) that influenced drip loss and others are controlled, one should not expect any statistical significance, which was indeed the case here.

Nutritionally speaking, poultry meat is a valuable source of proteins, and has a relatively low fat content. In that respect, the chemical composition of muscle tissue of major primal cuts is an important element of broiler meat quality (Ristić, 1999; Grashorn and Closterman, 2002; Bogosavljević-Bošković *et al.*, 2003). Thigh muscles have a lower protein content of about 15.50-17.20% (Simeonova, 1999) apart from having more fat. Bogosavljević-Bošković *et al.* (2003) have also reported 10.6 –15.6% of ether extract. The values reported in this study showed that the inclusion of the feed grade antibiotic increased the crude protein contents of the broilers while the fat was also expectedly reduced. This study corroborated the earlier findings of Hughes and Heritage (2004) that stated that antibiotics in animal

feeds result in a better meat quality with a reduced fat and increased protein contents. Mahmood *et al.* (2005) observed enhanced the crude protein with reduced fat contents with the use of probiotic and growth promoters. They also noted higher ash content in the control than those fed with growth promoters and probiotics. However, the values reported were different compared to this present study. They reported 28.92- 29.09%, 1.50- 3.66% and 1.66-2.11% for CP, EE and ash. These variations could be attributed to differences in sampling methods (Omojola and Adesehinwa, 2006), age, sex, genetic, and environmental factors (Bokkers and Koene, 2003).

Myoglobin content is a major factor contributing to meat colour and is dependent on species, muscle, and age of bird. Other intrinsic factors, such as muscle and pH, can also influence meat colour (Fletcher, 2002). However, in the present study, the inclusion of the graded levels of the feed grade antibiotics had no negative influence on the colour of the broiler chicken

Tenderness has also been identified as the most critical eating quality characteristic, which determines whether consumers are repeat buyers. It is defined as the sensory manifestation of the structure of meat and the manner in which this structure reacts to the force applied during biting and the specific senses involved in eating, (Fanatico *et al.*, 2007). The taste panelists recorded reduced values for the breast meat of the feed grade antibiotics. With the inclusion of the

antibiotic, the meat was rated between slightly tough and intermediate while the breast meat from the control diet was rated moderately tender. The diameter of the muscle fiber is positively related to the tenderness of the meat (Fanatico *et al.*, 2007). Extreme hypertrophy of muscle fibers is an indicator of poor meat quality (Rehfeldt *et al.*, 2004), and selection for a more moderate fiber is needed. The panelists rating were however supported by other studies who have reported that meat of slow-growing or older genotypes to be less tender compared with fast-growing (Castellini *et al.*, 2002; Wattanachant *et al.*, 2004; Fanatico *et al.*, 2005) but different from Farmer *et al.* (1997) who reported that breast meat from slow-growing birds was more tender than meat from fast-growing birds.

The values reported for juiciness by the consumer panel in this study disagree with previous researches in which breast meat from slow-growing birds was considered juicy (Fanatico *et al.*, 2005). This may be explained in part by the size of the breast fillet. Because the fillets from the slow-growing birds are smaller and thinner in dimension, they had relatively more surface area in relation to muscle mass exposed to the air, which likely caused higher drip loss (Fanatico *et al.*, 2005). Since the inclusion of antibiotic in the diet of animals has shown to reduce the fat contents (Hughes and Heritage, 2004) of meat which was also evident in this study, the reduced values observed with the inclusion antibiotic could be

justified. The reduction in the average score in juiciness with the inclusion of the antibiotics could also be linked to the lower WHC and higher cooking loss which have reduced the amount of juice released upon chewing.

Flavour and aroma are also thought to come from materials in fat, which volatilize when heated (Aberle *et al.*, 2001). The panelist reported a similar trend with juiciness with favour as the least value was seen in T5 (200mg/kg) while others with the inclusion of the antibiotic were rated to be *intermediate* but the flavor of the control was rated to be *slightly desirable*.

The experience of eating meat does not cause separate impressions of tenderness, juiciness, and flavour, but rather an overall impression (Aberle *et al.*, 2001). No influence was observed by the panelist on the effect of the inclusion of feed-grade antibiotic. It was rated as moderately liked. This means with or without antibiotic, consumer will still like the meat and will be willing to consume it. This is in agreement with Ristic (2003), who reported that production system did not affect overall sensory attributes. Moreover, Omojola *et al.* (2012) also stated that meat acceptability is mostly based on attractive colour, desirable flavour in the first instance, and on the combined effects of tenderness, juiciness and texture of a particular meat as evaluated by an individual consumer.

In conclusion, the inclusion of Tetracin® truly enhanced the crude protein and expectedly reduced the fat content of

the broiler meat. However, the physical properties of the meat were negatively affected with higher losses during cooking and lower WHC. This is an indication of losses in the nutritive value through exudates that are released and resulted in drier and tougher meat as experienced with the sensory analysis.

References

- A. M. S. A. 1995.** Research Guidelines for Cookery, Sensory Evaluation and Instrumental Measurements of fresh meat. National Livestock and Meat Board. Chicago, IL, USA.
- Aammer, M., Javid A. A. and Muhammad A. 2000.** Rational use of drugs in broiler meat production. *International Journal of Agriculture and Biology*, 2 (3): 269-272.
- Aberle, E. D., Forrest, J. C., Gerrard, D. E. and Mills, E. W. 2001.** Principles of Meat Science. 4th ed. Kendall/Hunt Publ. Co., Dubuque, IA.
- Abdullah, A. Y., Al-Beitawi, N. A., Rjoup, M. M. S., Qudsieh, R. I. and Ishmais, M. A. A. (2010).** Growth performance, carcass and meat quality characteristics of different commercial crosses of broiler strains of chicken. *Japan Poultry Science*, 47:13-21
- Akinwumi, A. O., Odunsi, A. A., Omojola, A. B. and Shittu, M. D. 2013a.** Assessment of antibiotic usage in some selected livestock farms of Oyo

- state, Southwest, Nigeria. *Nigeria Journal of Animal Science*. 15: 216-228.
- Akinwumi, A. O., Olatoye, I. O., Odunsi, A. A., Omojola, A. B., and Akinwale, P. B. 2013b.** A Study on Antibiotics Residue and Its Effects on Quality Properties of Chicken in South Western Nigeria. *International Journal of Applied Research and Technology*, 2, (7): 46–52.
- Akinwumi, A. O., Olatoye, I. O., Odunsi, A. A., Omojola, A. B., Rafiu, T. A and Oladunni, M. O. 2012.** Effects of antibiotic residue on the physical qualities of beef for human consumption in Oyo State, South West, Nigeria. Proceedings of 3rd International Conference on Agriculture and Animal Science (CAAS 2012) held in Bangkok, Thailand, November, 24-25, 2012. Ding Jie (Ed.) pp 73-76.
- AOAC, Association of Official Analytical Chemist. 2000.** *Official Methods of Analysis, Volume 2.* AOAC Inc., Virginia, USA, Helrich, K. (ed.). 17th edition.
- Awosanya, B. and Okubanjo A. O. 1993.** Effect of skinning, scalding or singeing on the physical characteristics of rabbit carcasses. *Nig. Food Jour.* 11: 147–152
- Berri, C., (2000).** Variability of sensory and processing qualities of poultry meat. *World's Poultry Science Journal* 56: 209–224.
- Bogosavljevic-Boskovic Snezana, Gajic Z, Mitrovic S, and Djokovic, R. 2003.** Meat Quality Parameters Selected in Yield of Carcasses and Parts of Broilers From Two Non-industrial Rearing Systems. 49th International Congress of Meat Science and Technology, Brazil, Proceedings: 41-42.
- Bokkers, E. A. M, and Koene, P. 2003.** Behaviour of fast- and slow growing broilers to 12 weeks of age and the physical consequences. *Appl. Anim. Behav. Sci.* 81: 59-72.
- Castellini, C., Mugnai, C and Dal Bosco, A. 2002.** Meat quality of three chicken genotypes reared according to the organic system. *Italian Journal of Food Science*, 14: 401–412.
- Costa, A. I. A., Teldeschi, E., Gerritzen, M. A., Reimert, H. G. M., Linssen, J. P. J., and Cone J. W. 2007.** Influence of flock treatment with the antibiotic tylosin on poultry meat quality: results of a preliminary experiment. *NJAS* 54 (3), 269–278.
- Dabes, A. C. (2001).** Propriedades da carne fresca. *Revista Nacional de Carne* 25:32–40.
- Demby, J. H., and Cunningham F. E. 1980.** Factors affecting composition of chicken meat-literature review. *World Poultry Science Journal*, 36: 25-37.
- Dubois, M., Fluchard, D., Sior E. and Delahaut, P. H. 2001.**

- Identification and Quantification of Five Macrolide Antibiotics in Several Tissues, Eggs and Milk by Liquid Chromatography-Electrospray Tandem Mass Spectrometry. *Journal of Chromatography B: Biomedical Sciences and Applications*, 753, (2): 189-202.
- Dransfield, E., and Sosnicki, A. A. 1999.** Relationship between muscle growth and poultry meat quality. *Poultry Science*, 78:743–746.
- Fakolade, P. O. 2007.** Physical characteristics of camel muscle compared with three breeds of cattle. *International Journal of Applied Agricultural and Apicultural Research (IJAAAR)*, 4(1&2): 14-19.
- Fanatico, A. C., Cavitt, L. C., Pillai, P. B., Emmert, J. L. and Owens, C. M. 2005.** Evaluation of slower-growing broiler genotypes grown with and without outdoor access: Meat quality. *Poultry Science*, 84:1785–1790.
- Fanatico, A. C., Pillai, P. B., Emmert, J. L. and Owens, C. M. 2007.** Meat quality of slow-growing chicken genotypes fed low-nutrient or standard diets and raised indoor or with outdoor access. *Poultry Science*, 86:2245 - 2255.
- Farmer, L. J., Perry, G. C., Lewis, P. D., Nute, G. R., Piggott, J. R. and Patterson, R. L. S. 1997.** Responses of two genotypes of chicken to the diets and stocking densities of conventional UK and label rouge production systems. II. Sensory attributes. *Meat Science*, 47:77–93.
- Fletcher, D. L. 2002.** Poultry meat quality. *Worlds Poultry Science Journal*, 58:131–145.
- Geidam, Y.A., Usman, H. Musa, H.I., Anosike F. and Adeyemi, Y. 2009.** Ox tetracycline and Procain Penicillin residues in tissues of slaughtered cattle in Maiduguri, Borno state, Nigeria. *Terrestrial Agua. Environ. Toxicol.*, 3(2): 68-70.
- Honickel, K. O., 1998.** Reference methods for the assessment of physical characteristics of meat. *Meat Science* 49: 447–457.
- Hughes, P. , and Heritage, J. 2004 .** Antibiotic growth promoters in food animals. In: *Assessing Quality and Safety of Animal Feeds*. FAO Animal Production and Health Papers Series No160. Food and Agriculture Organization of the United Nations (FAO), Rome, pp. 129–152.
- Klosowska, D. B., Rosinski, A. and Elminowska-Wenda, G. 1993.** Microstructural characteristics of the pectoralis muscle of white Italian geese. Pages 144–148 in: *Proceedings of the XI European Symposium on the Quality of Poultry Meat*. Vol 1. Tours, France.
- Latif, S., E. Dworschak, A. Lugasi, E.**

- Barna, A. Gergely, P. Czuczy, J. Hovari, M. Kontraszti, K. Neszlenyi, and Bodo, I. 1998.** Influence of different genotypes on the meat quality of chicken kept in intensive and extensive farmings. *Acta Alimentaria Budapest* 27:63-75.
- Malgorzata, S., Kazimierz, L., Henry, K. K, Jrry, W., Leszek, G., Joanna, Z., Arkadiusz, Z., Marek, K., Piotr, S., and Edyta, R. 2005.** The effect of cattle genotype on texture of selected muscles during post-mortem ageing. *Food Sci. and Tech. Elect. J. Pol. Agric Univ.* 8(3): 1-9.
- Mahmood, T., Anjum, M. S., Hussain, I. and Perveen, R. 2005.** Effect of probiotic and growth promoters on chemical composition of broiler carcass. *Int. J. Agric. Biol.* 7:1036-1037.
- Nisha, A. R. 2008.** Antibiotic residues: A global health hazard. *Veterinary World*, 1(12).
- Offer, G. and Trinick, J. 1983.** On the mechanism of water holding in Meat: The swelling and shrinking of myofibrils. *Meat Science*, 5,245-281.
- Offer, G., and Knight, P. 1988.** The structural basis of water-holding capacity in meat. Part 1: general principles and water uptake in meat processing. In R. Lawrie (Ed.). *Developments in meat science* (Vol. 4, pp. 61-171). New York: Elsevier Applied Science.
- Olatoye, I. O., and Ehinmowo, A. A 2009.** Oxytetracycline residue in edible tissues of cattle slaughtered in Akure, Nigeria. *International Journal of Food Safety*. 11:62-66.
- Omojola, A. B., Apata, E. S. and Fagbuaro, S. S. 2012.** Comparison of Skinning versus Scalding and Singeing: Effect on Temperature, pH and Meat Quality in Goats. *Journal of Animal Science Advances*, 2(9): 740-748.
- Omojola, A. B. and Adesehinwa, A. O. K. 2006.** Meat characteristics of scalded, singed and conventionally dressed rabbit carcass. *World Journal of Zoology*, 1 (1): 24-29.
- Qiaofen, C, and Da-Wen, S. 2005.** Application of PLSR in correlating physical and chemical properties of pork ham with different cooking methods. *Meat Sci.* 70: 691-698
- Rehfeldt, C., Fiedler, I. and Stickland, N. C. 2004.** Number of size of muscle fibres in relation to meat production. Pages 1- 38 in *Muscle Development of Livestock Animals: Physiology, Genetics and Meat Quality*. M. F. W. te Pas, M. E. Everts, and H. P. Haagsman, ed. CABI Publ., Cambridge, MA.
- Ristic, M. 1999.** Sensory and chemical

Effects of Graded levels of Tetracin® on Quality and Sensory Attributes of Broiler Meat

- criteria for broiler meat of different breeds from alternative levestock keeping. Proceedings of XIV European Symposium on the Quality of Poultry Meat, 19-23 September 1999, Bologna, Italy: 291-294.
- Ristic, M. 2003.** Quality of poultry meat obtained using different production systems and EU regulations for production and marketing of poultry carcasses. *Tehmol. Mesa* 44(3/4):149 – 158.
- SAS, 1999.** Statistical Analysis Institute Inc. (SAS) User's guide. Version: 9th Edition Statistical Analysis System Institute, Inc. Cary, N.C. USA.
- Simeonovová, J. 1999.** Technology of Poultry, Eggs and other Minor Animal Products (in Czech). MZLU, Brno: p. 247.
- Simon, A. H. and Baxter, G. A. 2006.** Biosensor screening for veterinary drug residues in food stuffs. *J. AOAC Int.*, 89(3): 862-867.
- Wattanachant, S., Benjakul, S. and Ledward, D. A. 2004.** Composition, color, and texture of Thai indigenous and broiler chicken muscles. *Poultry Science*, 83:123–128.
- Zeina, K., Pamela, A. K. and Fawwak, S. 2013.** Quantification of Antibiotic Residues and Determination of Antimicrobial Resistance Profiles of Microorganisms Isolated from Bovine Milk in Lebanon. *Food and Nutrition Sciences*, 4: 1-9.

Received: 26th October, 2016

Accepted: 17th March, 2017