



Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd



Document heading

doi: 10.1016/S2222-1808(14)60459-X

© 2014 by the Asian Pacific Journal of Tropical Disease. All rights reserved.

Effect of dietary supplementation with onion (*Allium cepa* L.) on performance, carcass traits and intestinal microflora composition in broiler chickens

Majid Goodarzi^{1*}, Shahram Nanekarani¹, Nasir Landy²¹Department of Animal Science, Broujerd Branch, Islamic Azad University, Broujerd, Iran²Young Researchers and Elite Club, Khorasgan Branch, Islamic Azad University, Isfahan, Iran

PEER REVIEW

Peer reviewer

Abbas Ali Gheisari, Assistant Professor, Department of Animal Science Research, Isfahan Research Center For Agriculture and Natural Resources, 81785-199, Esfahan, Iran.

Tel: +98 311 7885461

Fax: +98 311 7757022

E-mail: gheisari.ab@gmail.com

Comments

This is an interesting study in which the authors compared the efficacy of two levels of fresh onion bulbs a growth promoter agent on growth performance, carcass characteristics, and ileum microflora in broiler chickens when used as supplements in the diet. It seems that the work has been done with due care.

Details on Page S300

ABSTRACT

Objective: To examine the effect of onion (*Allium cepa* L.) as an antibiotic growth promoter substitute on growth performance, carcass traits, and microflora composition in broiler chickens.

Methods: A total of 192 one-day old mixed sex broiler chicks (Ross 308) were weighed and randomly allocated to four treatment groups, each with 4 replicate pens of 12 chicks. The dietary treatments consisted of the basal diet (control), antibiotic (15 mg virginiamycin/kg), and control+10 or 30 g fresh onions bulb/kg diet. Body weights of broilers were determined at Day 1, 21, and 42, feed intake was determined at the same periods, and feed conversion ratio was calculated accordingly. At Day 42, two birds per replicate were slaughtered for determination of carcass and organ weights. The populations of *Lactobacilli* spp. and *Escherichia coli* were enumerated in ileum by conventional microbiological techniques using selective agar media.

Results: Dietary supplementation of 30 g/kg onion increased final body weight of broilers at 42 d of age compared to that of the other treatments ($P<0.05$). Birds fed 30 g onion/kg in the diet had the highest feed intake than other treatments at different growth periods ($P<0.05$). Feed conversion ratio, carcass yield and internal organ weights were not affected by the dietary treatments at Day 42. The *Lactobacilli* spp. population in birds supplemented with onion at the level of 30 g/kg significantly was higher than other groups at 42 d of age ($P<0.05$). The lowest *Escherichia coli* loads were detected in broilers fed diets containing 15 mg virginiamycin/kg. The *Escherichia coli* loads significantly decreased in broilers fed diets containing 10 or 30 g onion/kg ($P<0.05$).

Conclusions: In conclusion, the results of the current study indicated that supplementing broiler diet with 30 g onion/kg could induce favorable influences on performance and ileum microflora composition.

KEYWORDS

Allium cepa L., Broiler, Performance, Carcass characteristics, Intestinal microflora composition

1. Introduction

Antibiotic growth promoters are used worldwide within the poultry industry to promote growth performance and protect flock health[1-3]. Antibiotic growth promoters were supposed to increase growth rate as a result of improved gut health, resulting in better nutrient utilization and decreased feed conversion ratio[4]. However, the use of

dietary antibiotics have resulted in controversial problems such as development of antibiotic resistant bacterial[5], and drug residue in the final products[6] which can be harmful to consumers. Thus, the use of antibiotics as a growth promoter is no longer acceptable and it is forbidden in European Union countries. As a consequence, it has become necessary to develop alternative substances and strategies for animal growth promotion and disease prevention.

*Corresponding author: Majid Goodarzi, Department of Animal Science, Broujerd Branch, Islamic Azad University, Broujerd, Iran.

Tel: +98 916 665 3248

Fax: +98 311 5354038

E-mail: majidgoodarzi117@gmail.com

Foundation Project: Financially supported by the Islamic Azad University, Broujerd Branch (Grant No. 83567).

Article history:

Received 29 Nov 2013

Received in revised form 12 Dec, 2nd revised form 15 Dec, 3rd revised form 22 Dec 2013

Accepted 10 Jan 2014

Available online 28 Jan 2014

Phytogenic and herbal products, also known phytobiotic products which are plant derived products, used in animal feeding to improve performance through amelioration of feed properties, promotion of production performance, and improving the quality of animal origin food[7,8].

The genus *Allium* includes about 550 species. A few of these are important as food plants and as drugs in folk medicine, especially onion [*Allium cepa* L. (*A. cepa*)] and garlic [*Allium sativum* L. (*A. sativum*)]. Onion is a bulbous plant widely cultivated in almost every country of the world with leading production in China, India and the United States[9]. Onion bulbs possess numerous organic sulphur compounds including trans-S-(1-propenyl) cysteine sulfoxide, s-methyl-cysteine sulfoxide, spropylcysteine sulfoxides and cycloallicin, flavinoids, phenolic acids, sterols including cholesterol, stigma sterol, b-sitosterol, saponins, sugars and a trace of volatile oil compounds mainly of sulphur compounds[10]. Most of the plant parts contain compounds with proven antibacterial, antiviral, antiparasitic, antifungal properties and has antihypertensive, hypoglycemic, antithrombotic, antihyperlipidemic, anti-inflammatory and antioxidant activity[11].

Aji *et al.* observed the beneficial influence of onion bulbs on growth performance of broiler chickens[12]. Despite these findings, there has been a dearth of information on the effect of fresh onion bulbs on performance, carcass traits, and intestinal microflora in comparison with an antibiotic growth promoter in broiler chickens. Therefore, the present study was designed to compare the efficacy of two levels of fresh onion bulbs a growth promoter agent on growth performance, carcass characteristics, and ileum microflora in broiler chickens when used as supplements in the diet.

2. Materials and methods

2.1. Animals and dietary treatments

One hundred ninety two, one-day old broiler chickens of mixed sex (Ross-308) were weighed and randomly assigned to each of the four treatment groups, each with 4 replicate pens of 12 chicks. The dietary treatments included the basal diet (control), control+15 mg virginiamycin/kg, or control+10 or 30 g fresh onions (*A. cepa*) bulb/kg diet.

Table 1 lists the basal diet formulated according to nutrient requirements of broilers provided by National Research Council[13]. The birds were fed a starter diet from 0 to 21 d and grower diet from 22 to 42 d. All the dietary treatments were added to the basal diets at the expense of sand. Chicks were raised on floor pens (120 cm×120 cm×80 cm) for 6 weeks and had free access to feed and water throughout the entire experimental period. The lighting program consisted of a period of 23 h light and 1 h of darkness. The ambient temperature in experimental house was maintained at 32 °C during the first week and gradually decreased by 3 °C in the

second and third weeks, and finally fixed at 22 °C thereafter.

Table 1

The ingredient and calculated composition of basal starter and grower diets.

Item		Starter	Grower
Ingredient (g/kg)	Corn	505.1	524.6
	Soybean meal	385.0	350.0
	Soybean oil	35.8	59.0
	Mono calcium phosphate	14.2	10.0
	CaCO ₃	17.3	16.7
	NaCl	3.1	2.1
	NaHCO ₃	2.0	1.6
	Trace mineral premix ¹	2.5	2.5
	Vitamin premix ²	2.5	2.5
	DL-methionine	2.5	1.0
	L-lysine	–	–
	Sand	30.0	30.0
	Calculated composition	Metabolizable energy (kcal/kg)	2900.0
Crude protein (g/kg)		215.0	200.0
Calcium (g/kg)		10.0	9.0
Available phosphorus (g/kg)		4.5	3.5
Methionine+cysteine (g/kg)		9.0	7.2
Lysine (g/kg)		11.8	10.9

¹Provided the following per kg of diet: Mg 56 mg; Fe 20 mg; Cu 10 mg; Zn 50 mg; Co 125 mg; I 0.8 mg. ²Provided the following per kg of diet: vitamin A 10000 IU; vitamin D3 2000 IU; vitamin E 5 IU; vitamin K 2 mg; riboflavin 4.20 mg; vitamin B12 0.01 mg; pantothenic acid 5 mg; nicotinic acid 20 mg; folic acid 0.5 mg; choline 3 mg.

2.2. Performance and carcass components

Body weights of broilers were determined at Day 1, 21, and 42 of age. Feed intake and weight gain were recorded in different periods and feed conversion ratio (FCR) was calculated. Mortality was recorded as it occurred and was used to adjust the total number of birds to determine the total feed intake per bird and FCR. At 42 d of age, two birds per replicate were randomly chosen, based on the average weight of the group and slaughtered through cutting carotid arteries and partial slicing of the neck by a manual neck cutter. Carcass yield was calculated by dividing eviscerated weight by live weight. Abdominal fat, liver, and pancreas were collected, weighed and calculated as a percentage of live body weight.

2.3. Enumeration of bacteria populations in ileum

Intestinal samples were collected and fresh digesta samples from ileum were taken for bacterial analyses within 1 h from collection. Digesta samples were serially diluted in 0.85% sterile saline solution for enumeration of *Lactobacilli* spp. and *Escherichia coli* (*E. coli*) by conventional microbiological techniques using selective agar media. All microbiological analyses were performed in duplicate and the average values were used for statistical analysis.

Lactobacilli spp. were anaerobically assayed using MRS agar (Fluka 80961). *Lactobacilli* spp. was confirmed by using API 50 CH kit (Biomérieux_ SA, Marcy-l'Étoile/France). *E.*

coli were enumerated through the use of Plate Count MUG Agar (Fluka 80961) and TBX Agar (Fluka 92435). Results were expressed as base–10 logarithm colony–forming units per gram of ileal.

2.4. Statistical analysis

The data were subjected to analysis of variance procedures appropriate for a completely randomized design using the general linear model procedures of SAS (SAS Inst. Inc., Cary, NC, USA). The mean differences among different treatments were separated by Duncan's multiple range tests. A level of ($P<0.05$) was used as the criterion for statistical significance.

3. Results

3.1. Performance and carcass traits

Impact of dietary treatments on growth performance indices from Day 1 to 42 of age is presented in Table 2.

Table 2

Effect of experimental diets on performance indices of broilers at different ages.

Performance parameters	Days	Dietary treatments				SEM
		Control	Virginiamycin	10 g/kg Onion	30 g/kg Onion	
Daily Feed	0–21 d	31.40 ^{ab}	31.40 ^{ab}	29.40 ^b	32.60 ^a	0.330
Intake (g per bird/day)	21–42 d	122.50 ^b	124.50 ^b	128.90 ^{ab}	133.50 ^a	1.190
	0–42 d	77.00 ^b	78.00 ^b	79.20 ^{ab}	83.00 ^a	0.690
Feed	0–21 d	1.53 ^{ab}	1.56 ^a	1.51 ^b	1.51 ^b	0.005
Conversion	21–42 d	1.87	1.89	1.92	1.89	0.014
Ratio (g/g)	0–42 d	1.79	1.81	1.83	1.81	1.010
Body Weight (g)	21 d	465.80	463.80	447.10	477.50	4.790
	42 d	1838.30 ^b	1845.20 ^b	1859.20 ^b	1955.10 ^a	14.840

Values in the same row not sharing a common superscript differ significantly ($P<0.05$). SEM: standard error of mean.

At 21 d of age, body weight of chicks did not differ between the dietary treatments, although body weight of broiler supplemented with 30 g onion/kg was higher than other groups. At the end of the trial (Day 42), birds supplemented with the 30 g onion/kg had a greater body weight compared with other groups ($P<0.05$). The average daily feed intake (ADFI) (from Day 1 to 21) was increased ($P<0.05$) for bird supplemented with 30 g onion/kg of diet. The ADFI during grower and entire experimental period was higher for broilers supplemented with 30 g onion/kg compared with control birds and birds supplemented with antibiotic ($P<0.05$). Broilers receiving 10 or 30 g onion/kg had lower feed conversion ratio (FCR) compared to broilers receiving antibiotic during starter period ($P<0.05$), but FCR of broilers in other periods was not affected. No differences because of treatment effects were observed on mortality.

Table 3 shows carcass, abdominal fat, liver and pancreas as a percentage of live body weight at slaughter. Carcass yield and relative organ weight were not markedly affected by dietary treatments.

Table 3

Effect of experimental diets on carcass yield and relative organ weight of broilers at 42 d.

Relative organ weight	Dietary treatments				SEM
	Control	Virginiamycin	10 g/kg Onion	30 g/kg Onion	
Carcass (%)	73.0	72.9	72.9	73.9	0.31
Liver (%)	3.40	3.30	3.15	3.19	0.04
Pancreas (%)	0.365	0.356	0.372	0.318	0.01
Abdominal fat (%)	2.35	2.09	2.05	2.04	0.09

SEM: standard error of mean.

3.2. Intestinal microflora

Data on ileum bacteria populations of broiler chicks at Day 42 of age are summarized in Table 4. The *Lactobacilli* spp. population in birds supplemented with onion at the level of 30 g/kg was significantly higher than control birds and birds supplemented with 10 g onion/kg at 42 d ($P<0.05$). The *Lactobacilli* spp. population increased ($P<0.05$) for birds supplemented with antibiotic compared with control birds and birds supplemented with 10 g onion/kg. Notable reduction in *E. coli* was found in broilers supplemented with antibiotic compared to other groups ($P<0.05$). *E. coli* loads significantly decreased in broilers fed diets containing 10 or 30 g onion/kg than control birds ($P<0.05$).

Table 4

Effects of dietary treatments on ileum bacteria populations of broiler chicks at d 42 of age.

Variable	Dietary treatments				SEM
	Control	Virginiamycin	10 g/kg Onion	30 g/kg Onion	
<i>E. coli</i>	7.35 ^a	5.45 ^d	6.98 ^b	6.43 ^c	0.12
<i>Lactobacilli</i> spp.	4.98 ^d	5.53 ^{ab}	5.05 ^{dc}	5.68 ^a	0.06

Values in the same row not sharing a common superscript differ significantly ($P<0.05$). SEM: standard error of mean.

4. Discussion

The body weight of birds obtained in this study was lower than the strain standard at different ages. This project was performed in Broujerd Azad University research farm, which is located around Broujerd city, with an altitude of 1620 m. According to Julian^[14], the partial pressure of oxygen drops approximately 7 mm Hg for each 1000 m increase in altitude, equivalent to a drop of 2.5% in the air oxygen. Landy *et al.* showed that the broilers raised under low pressure atmospheric O₂, growth rate is retarded due to a depression in feed intake^[8]. Also in other trials, final body weight of broilers reared in high altitude was lower than standard target weight^[15–17]. Thus, besides feeding a mash diet, to a large extent, the relatively high altitude could account for the decreased growth rate of broilers at different ages. Because of foregoing problems, our chicks

did not reach the target weight for Ross 308 and had lower weights at different ages. Dietary supplementation of 30 g/kg onion increased body weight and feed intake of broilers at different growth periods. Broilers receiving 10 or 30 g onion/kg had lower FCR compared to broilers receiving antibiotic during starter period ($P < 0.05$), but FCR of broilers in other periods was not affected. As antibiotics, herbs and phytogetic products could control and limit the growth and colonization of a variety of pathogenic and nonpathogenic species of bacteria in chicks' gut. This may lead to a greater efficiency in the utilization of feed, resulting in increased growth and improved feed efficiency^[18]. In this trial, the positive impact of the onion on the feed utilization was observed at starter period, but the improved FCR obtained in broilers supplemented with 30 g onion/kg was not reflected at grower period probably due to the facts that older birds' nutrient requirements decrease with age and also they have a better developed digestive tracts and organs^[17]. Fresh bulbs of *A. cepa* consist mainly of water (about 88%), saccharides (about 6%) and proteins (about 1.5%). However, the particular composition depends on a large number of factors, such as growing conditions, time of harvest and length and conditions of storage^[19]. *A. cepa* is a rich source of various compounds and has been thoroughly investigated by phytochemists during the last 100 years. Like other species of the genus *Allium*, e.g. *Allium sativum* or *Allium ursinum*, *A. cepa* is especially characterized by a high content of organosulphur compounds. The most predominant of these genuine sulphur-containing compounds are the amino acids cysteine and methionine, the S-alk(en)yl-substituted cysteine sulphoxides and the γ -glutamyl peptides^[20]. The improve growth performance of chicks receiving 30 g onion/kg could be due to content of organosulphur compounds of onion. Similar to our results, Aji *et al.* reported an enhancement in body weight, FCR and ADFI of broilers offered diets containing fresh onion bulbs in comparison with broilers fed basal diet^[12]. Unfortunately, no other reports are available on the effects of onion on bird growth performance.

Carcass yield and relative organ weight were not markedly affected by dietary treatments. These results are consistent with those reported by Aji *et al.* who did not find any differences among the control treatment and those containing onion on carcass yield of 21-day old broilers^[12]. In another study, carcass and organ characteristics of broilers fed dies supplemented with garlic were not affected by dietary treatments^[21]. Similar results were observed for feeding garlic to pigs and supplementation of broiler diet with antibiotics and probiotics^[22,23].

The *Lactobacilli* spp. population in birds supplemented with onion at the level of 30 g/kg significantly was higher, and *E. coli* loads was lower than other groups at 42 d of age ($P < 0.05$). The lowest *E. coli* loads were observed in broilers fed diets containing 15 mg virginiamycin/kg. Antibiotics may control and limit the growth and colonization of a variety of pathogenic and nonpathogenic species of bacteria in chicks gut^[24]. Hannan *et al.* reported antimicrobial activity of onion extract against *Vibrio cholerae*^[25]. In other trials, ethanolic extract of onion gave 11 mm zone of

inhibition with minimum inhibitory concentration (MIC) 0.8 mg/mL against *Pseudomonas aeruginosa* and 9 mm zone of inhibition with MIC 0.8 mg/mL^[26,27]. The same results were obtained in another study conducted by Sharma *et al.* in India in 2009^[28]. The MIC was determined by disc diffusion method^[28]. The onion bulbs contain numerous organic sulphur compounds. Thus, the presence of these compounds may explain the antimicrobial activity of this plant^[10]. In conclusion, the results indicate that supplementing broiler diet with 30 g onion/kg could induce favorable influences on performance and ileum microflora composition.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

This study was financially supported by the Islamic Azad University, Broujerd Branch (Grant No. 83567).

Comments

Background

The use of phytobiotics as alternatives to antibiotic growth promoters in animal diets is still an interesting approach. From this point of view the present paper is of interest. In general, the paper adds to the current knowledge in this field and is sufficiently prepared to be recommended for acceptance. Some comments were inserted in the manuscript which should be considered by authors before acceptance.

Research frontiers

The present study was designed to compare the efficacy of two levels of fresh onion bulbs a growth promoter agent on growth performance, carcass characteristics, and ileum microflora in broiler chickens when used as supplements in the diet.

Related reports

Landy *et al.* showed that the broilers raised under low pressure atmospheric O₂, growth rate is retarded due to a depression in feed intake. Aji *et al.* reported an enhancement in body weight, FCR and ADFI of broilers offered diets containing fresh onion bulbs in comparison with broilers fed basal diet.

Innovations & breakthroughs

The study finds that supplementing broiler diet with 30 g onion/kg could induce favorable influences on performance and ileum microflora composition.

Applications

The results of the current study indicated that supplementing broiler diet with 30 g onion/kg could induce favorable influences on performance and ileum microflora

composition. It will be useful for the researchers in further study.

Peer review

This is an interesting study in which the authors compared the efficacy of two levels of fresh onion bulbs a growth promoter agent on growth performance, carcass characteristics, and ileum microflora in broiler chickens when used as supplements in the diet. It seems that the work has been done with due care.

References

- [1] Ghalamkari GH, Toghyani M, Landy N, Tavalaeian E. Investigation the effects using different levels of *Mentha pulegium* L. (pennyroyal) in comparison with an antibiotic growth promoter on performance, carcass traits and immune responses in broiler chickens. *Asian Pac J Trop Biomed* 2012; **2**(Suppl 3): S1396–S1399.
- [2] Engberg RM, Hedemann MS, Leser TD, Jensen BB. Effect of zinc bacitracin and salinomycin on intestinal microflora and performance of broilers. *Poult Sci* 2000; **79**: 1311–1319.
- [3] Nanekarani S, Goodarzi M, Heidari M, Landy N. Efficiency of ethanolic extract of peppermint (*Mentha piperita*) as an antibiotic growth promoter substitution on performance, and carcass characteristics in broiler chickens. *Asian Pac J Trop Biomed* 2012; **2**(Suppl 3): S1611–S1614.
- [4] Visek WJ. The mode of growth promotion by antibiotics. *J Anim Sci* 1978; **46**: 1447–1469.
- [5] Nasir Z, Grashorn MA. Use of black cumin (*Nigella sativa*) as alternative to antibiotics in poultry diets. Proceedings of the 9th Tagung schweine-und geflügelernährung; 2006, p. 210–213. Halle, Germany.
- [6] Burgat V. [Residues of drugs of veterinary use in food]. *Rev Part* 1999; **41**: 985–990. French.
- [7] Toghyani M, Toghyani M, Gheisari AA, Ghalamkari GH, Mohammadrezaei M. Growth performance, serum biochemistry, and blood hematology of broiler chicks fed different levels of black seed (*Nigella sativa*) and peppermint (*Mentha piperita*). *Livest Sci* 2010; **129**: 173–178.
- [8] Landy N, Ghalamkari GH, Toghyani M. Performance, carcass characteristics and immunity in broiler chicks fed dietary neem (*Melia azadirachta*) as alternative for an antibiotic growth promoter. *Livest Sci* 2011; **142**: 305–309.
- [9] Ebesunun MO, Popoola OO, Aghedana EO, Olisekodiaka JM, Onuegbu JA, Onyeagala AA. The effect of garlic on plasma lipids and lipoproteins in rats fed on high cholesterol enriched diet. *Biokemistri* 2007; **19**: 53–58.
- [10] Melvin JM, Jayochitra J, Vijayapriya M. Antimicrobial activity of some common spices against certain human pathogens. *J Med Plants Res* 2009; **3**: 1134–1136.
- [11] Lampe JW. Health effects of vegetables and fruits: assessing mechanisms of action in human experimental studies. *Am J Clin Nutr* 1999; **70**(Suppl 3): S475–S490.
- [12] Aji SB, Ignatius K, Ado AA, Nuhu JB, Abdulkarim A, Aliyu U, et al. Feeding onion (*Allium cepa*) and garlic (*Allium sativum*) on some performance characteristics of broiler chickens. *Res J Poult Sci* 2011; **4**: 22–27.
- [13] Subcommittee on Poultry Nutrition, National Research Council. *Nutrient requirements of poultry*. 9th ed. Washington DC: National Academy Press; 1994.
- [14] Julian RJ. The response of heart and pulmonary arteries to hypoxia, pressure and volume: a short review. *Poult Sci* 2007; **86**: 1006–1011.
- [15] Landy N, Ghalamkari GH, Toghyani M, Moattar F. The effects of *Echinacea purpurea* L. (purple coneflower) as an antibiotic growth promoter substitution on performance, carcass characteristics and humoral immune response in broiler chickens. *J Med Plants Res* 2011; **5**: 2332–2338.
- [16] Landy N, Ghalamkari GH, Toghyani M. Evaluation of St John's Wort (*Hypericum perforatum* L.) as an antibiotic growth promoter substitution on performance, carcass characteristics, some of the immune responses, and serum biochemical parameters of broiler chicks. *J Med Plants Res* 2012; **6**: 510–515.
- [17] Toghyani M, Toghyani M, Gheisari AA, Ghalamkari GH, Eghbalsaied SH. Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. *Livest Sci* 2011; **138**: 167–173.
- [18] Bedford M. Removal of antibiotic growth promoters from poultry diets. *World's Poult Sci J* 2000; **56**: 347–365.
- [19] Watt BK, Merrill AL. *Composition of foods: raw, processed, prepared*. Washington DC: U.S. Department of Agriculture; 1963.
- [20] Steinegger E, Sticher O, Hänsel R. *Pharmakognosie-phytopharmazie*. Berlin: Aufl Springer Verlag; 1999.
- [21] Gbenga EO, Oluwatoyin EA, Adebowale NF, Ayodeji VA. Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. *Afr J Agric Res* 2009; **4**: 511–517.
- [22] Cullen SP, Monahan FJ, Callan JJ, Doherty JV. The effect of dietary garlic and rosemary on grower-finisher pig performance and sensory characteristics of prok. *Irish J Agric Food Res* 2005; **44**: 57–67.
- [23] Contreas-Castillo CJ, Brossi C, Previero C, Dematte LC. Performance and carcass quality of broilers supplemented with antibiotics or probiotics. *Braz J Poult Sci* 2008; **10**: 227–232.
- [24] Ferket PR. Alternatives to antibiotics in poultry production. In: Lyons TP, Jacques KA, editors. *Nutritional biotechnology in the feed and food industries*. Nottingham: E-publishing Inc; 2004, p. 57–67.
- [25] Hannan A, Humayun T, Hussain MB, Yasir M, Sikandar S. *In vitro* antibacterial activity of onion (*Allium cepa*) against clinical isolates of vibrio cholera. *J Ayub Med Coll Abbottabad* 2010; **22**: 160–163.
- [26] Azu NC, Reginald A, Okoro N, Kalu J. Antibacterial activity of *Allium cepa* (onions) and *Zingiber officinale* (ginger) on *Staphylococcus aureus* and *Pseudomonas aeruginosa* isolated from high vaginal swab. *Internet J Trop Med* 2007; **2**: 1540–2681.
- [27] Azu NC, Onyeagba Ra. Antimicrobial properties of extracts of *Allium cepa* (onions) and *Zingiber officinale* (ginger) on *Escherichia coli*, *Salmonella typhi* and *Bacillus subtilis*. *Internet J Trop Med* 2007; **3**: 351–372.
- [28] Sharma A, Kumar P, Chaturvedi N. Vibriocidal activity of certain medicinal plants used in Indian folklore medicine by tribals of Mahakoshal region of central India. *Indian J Pharmacol* 2009; **41**: 129–133.