Original research paper

QUALITY OF BROILER CHICKENS CARCASS FED DIETARY ADDITION OF GARLIC, BLACK PEPPER AND HOT RED PEPPER

Nikola Puvača[1,*], Dragana Ljubojević Pelić[2], Ivana Čabarkapa[3], Sanja Popović[3], Zorica Tomičić[3], Nedeljka Nikolova[4], Jovanka Lević[3]

[1]University Business Academy, Faculty of Economics and Engineering Management, Department of Engineering Management in Biotechnology, Cvećarska 2, 21000 Novi Sad, Serbia
[2]Scientific Institute of Veterinary Medicine "Novi Sad", Rumenački put 20, 21000 Novi Sad, Serbia
[3]University of Novi Sad, Scientific Institute for Food Technology, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia
[4]Ss Cyril and Methodius University in Skopje, Institute of Animal Science, Bul. Ile Ilievski 92a, 1000 Skopje, North Macedonia

*Corresponding author:
E-mail address: nikola.puvaca@fimek.edu.rs

ABSTRACT: Aim of this study was to investigate the effect of natural growth promoters such as garlic, black pepper and hot red pepper in broiler chicken nutrition on production performances and chicken carcass quality. At the beginning of the experiment, a total of 1200 one-day old Hubbard broilers were totally randomly distributed into eight dietary treatments with four replicates each. For nutrition of chicks three mixtures were used, starter, grower and finisher. Dietary mixtures in the experiments was as follows: T1 (Control diet), T2 (Garlic powder 0.5 g/100g), T3 (Garlic powder 1.0 g/100g), T4 (Black pepper powder 0.5 g/100g), T5 (Black pepper powder 1.0 g/100g), T6 (Hot red pepper 0.5 g/100g), T7 (Hot red pepper 1.0 g/100g) and T8 (Mixture of spices in ratio of 1:1:1 in total amount of 0.5 g/100g). Addition of spices significantly ($p<0.05$) influenced on production parameters and carcass quality of broiler chickens. The highest achieved body weight of chicken was in treatment T6 (2460.6 g) which was followed by treatment T7 (2442.4 g) with statistically significant differences ($p<0.05$) compared to other treatments. In carcass which was ready for roasting, highest yield was recorded in dietary treatment T7 (1829.8 g) which was statistically significant ($p<0.05$) higher compared to treatments T1 (1626.5 g), T3 (1710.7 g), T4 (1532.2 g) and T5 (1587.5 g), respectively. The primal cuts of the most economically important value such as drumsticks with thighs had the highest weights in treatments T7 (530.7 g), T6 (525.2 g), T2 (520.2 g) and T8 (497.1 g), with statistically significant differences ($p<0.05$) compared to treatments T4, T5 and T1 (438.5 g, 448.7 g and 461.1 g). It can be concluded that the addition of garlic, black pepper and hot red pepper in broiler chicken nutrition has positive effect on production performances and in improvement of chicken carcass quality which will be more acceptable by the consumers.

Key words: *chicken, meat, nutrition, spices, quality*

INTRODUCTION

Over the years, the past few decades, the use of antibiotic as growth promoters in poultry nutrition has been associated with fast growing nature of broiler chickens and their short generation interval in order to improve the quality of the final product

(Schwarz et al., 2001; Sarica et al., 2005; Puvača et al., 2013). Although chicken reared with addition of antibiotics achieved good performance on one side but on the other side their potential side effects became a real public health problem worldwide (Donoghue, 2003). To improve chicken healthiness and to fulfil consumer expectations in relation to food quality, poultry producers nowadays commonly apply natural dietary supplements mainly medical, aromatic and spice herbs (Onibi et al., 2009; Popović et al., 2018). The positive effects of herbal supplements or phytoadditves on broiler performance (Amooz Mehr and Dastar, 2009), carcass and meat quality (Khalafalla et al., 2011) have been demonstrated. The chicken products quality on the market is increasingly valued by consumers. To ensure optimum quality, it is necessary to consider the entire production chain process from farm to plate. Many studies focused on the impact of many dietary supplemental components such as vitamin E (Li et al., 2009), selenium (Puvača and Stanaćev, 2011), medical (Kostadinović et al., 2015) and spice and herbs (Fayed et al., 2011; Abou-Elkhair et al., 2014) on post-mortem meat quality. Garlic (*Allium sativum* L.) have been widely used as herbal supplement in broiler chicken diet because of its strong stimulating effect on the immune system and the very rich aromatic oils which enhance feed digestion (Gardzielewska et al., 2013). Black pepper (*Piper nigrum* L.) in broiler nutrition had influence on improved health status, increase absorption of selenium, vitamin B complex, enhances the thermogenesis of lipids and accelerates energy metabolism in the body (Al-Kassie et al., 2011). Hot red pepper (*Capsicum annuum* L.) plays an important role in decreasing the deposition of cholesterol and fat in the body, contributes to decreased levels of triglycerides and supports the vascular system in the body (Puvača et al., 2015). All of these spices and herbs exhibits antiatherosclerotic, antimicrobial, hypolipidemic, antithrombotic, antidiabetic effects (Mansoub, 2011); antioxidant, anticarcinogenic, antiinflammatory effects (Pradeep and Kuttan, 2004); chemopreventive and chemotherapeutic effects (Al-Kassie et al., 2011), and also exhibits positive effect on broilers production and blood lipid profile (Puvača et al., 2015).

A world trend to reduce the usage of antibiotics in poultry nutrition due to residues problems in the final products is evident, so the aim of this study is to investigate and shows the effect of natural growth promoters such as garlic, black pepper and hot red pepper in broiler chicken nutrition on production performances and chicken carcass quality.

MATERIAL AND METHODS

Animals and housing

Biological tests were carried out under production conditions at the experimental farm "Pustara" in property of the Faculty of Agriculture, Department of Animal Science in Novi Sad. At the beginning of the experiment, a total of 1200 one-day old Hubbard broilers were totally randomly distributed into eight dietary treatments with four replicates each. Chickens were reared on floor holding system with the chopped straw as litter material. Chickens were provided with the light regime of 23h of day per entire experimental period of 42 days. Heating of chickens was provided locally with the infrared light heaters and the whole house was supplied with 2 thermometers linked to the heather ventilation controls. House temperature zones were preheated to the temperature between 31-33°C before delivery and receiving of chickens, and the temperature was maintained during the first week. Every next week temperature was decreased for about 2°C, reaching 20-22°C at the end of 6th week of the experiment.

Chickens were fed through pan feeders and watered through the nipple water system. Microclimate conditions during the 42 days of the experiment were regularly monitored. Body weight was monitored at an individual level during the entire experimental period every seven days, while the feed consumption and feed conversion ratio were monitored at the pen level also every seven days.

Diet and feeding

At the beginning of the experiment eight dietary in four replicates were formed. Every dietary treatment included 150 chickens, which were divided in four pens with 37-38 chicken per each pen. For nutrition of chicks three mixtures were used, starter, grower and finisher. For the first 14 days, during the preparatory period, chicks were fed with starter mixture based on the corn and soybean meal. Following the preparation period, chicks were fed with grower mixtures for the next 21 days, and then for the last 7 days of fattening period with finisher mixtures of composition and nutritive value which is given in Table 1. Dietary mixtures in the experiments was as follows: T1 (Control diet), T2 (Garlic powder 0.5 g/100g), T3 (Garlic powder 1.0 g/100g), T4 (Black pepper powder 0.5 g/100g), T5 (Black pepper powder 1.0 g/100g), T6 (Hot red pepper 0.5 g/100g), T7 (Hot red pepper 1.0 g/100g) and T8 (Mixture of spices in ratio of 1:1:1 in total amount of 0.5 g/100g). During the experiment chicks were fed and watered ad libitum.

Table 1. Composition and nutritive value of dietary mixtures, g/100g

Indices	Diet mixtures		
	Starter	Grower	Finisher
Ingredients			
Corn	55.0	54.2	57.1
Wheat	5.0	8.0	12.0
Soybean meal, 44%	19.5	19.0	9.9
Soy protein concentrate	8.8	5.7	7.8
Sunflower meal, 42%	2.0	4.0	6.0
Corn gluten	2.0	2.0	-
Yeast	1.5	-	-
Chalk	1.75	1.70	1.50
Monocalcium phosphate	1.38	1.22	0.98
Premix	2.57	2.58	2.32
Chemical composition			
Dry matter	89.4	89.3	89.4
Moisture	10.5	10.7	10.5
Crude protein	21.1	20.7	17.3
Crude fat	3.9	3.9	4.7
Crude fibre	3.5	3.5	3.6
Crude ash	5.0	4.8	5.6
Ca	0.8	0.9	1.1
P	0.6	0.6	0.5
Metabolisable Energy, MJ/kg	12.5	12.8	13.3

Sample preparation

At the end of 42 days of the experiment, twelve broiler chicken, six male and six female of an average body weight of each treatment was selected for the investigation of carcass quality. Before slaughtering broilers chicken were starved for 12 hours, and afterword slaughtered were processed by bloodletting, scalding, plucking and evisceration and chilled. Immediately prior to slaughter, the broilers were weighed. Upon slaughter, dressed carcasses were subjected to measurements. Dressed cold carcasses were dissected into primal cuts such as breast, drumsticks with thighs, wings, back, head, neck and legs following the method prescribed by the Regulation on Poultry Meat Quality. Primal cuts were weighed to determine the dressing percentage of the tested broilers chickens. The data obtained were used to calculate the share of individual meat classes. Breast and drumsticks with thighs were stored for further analysis of nutritive, technological and sensory meat quality. Also the influence of dietary treatments was investigated in the share of edible offal's such as liver, gizzard, spleen and hearth, as well as the share of the carcass abdominal fat pad.

Statistical analysis

Statistical analyses were conducted within statistical software program Statistica 12 for Windows, to determine if variables differed between treatments. Significant effects were further explored using analysis of variance (ANOVA) with repeated measurements, least square means (LSM) and standard errors of least square means (SE_{LSM}), as well as Fisher's LSD post-hoc multiple range test with Bonferroni corrections to ascertain differences among treatment means. A significance level of $p<0.05$ was used.

RESULTS AND DISCUSSION

Based on the gained results it can be concluded that the dietary addition of garlic, black pepper and hot red pepper in broiler chickens nutrition led to a statistically significant ($p<0.05$) differences in final body weight (Table 2). Chickens have finished the preparatory period with uniform body weight with no statistical significant differences ($p>0.05$) and entered in experimental phase with almost equal body weights. After the completion of the experimental period, the highest achieved body weight of chicken was in treatment T6 (2460.6 g) which was followed by treatment T7 (2442.4 g) with statistically significant differences ($p<0.05$) compared to other treatments. Treatments with addition of garlic powder (T2, T3) achieved final body masses of 2371.1 and 2336.1 g which were statistically significantly ($p<0.05$) higher than masses of chickens in treatments T1 (2075.8 g), T4 (2076.5 g) and T5 (2077.5 g). Addition of black pepper in treatments T4 and T5 led to a statistically significant ($p<0.05$) lower body weight compared to other experimental treatments but without significant differences ($p>0.05$) compared to the control treatment T1. In this experiment, for the entire experimental period, feed conversion ratio was the lowest in treatments T2 and T5 (1.8 kg/kg) and the highest in control treatment T1 (2.1 kg/kg), without statistically significant ($p>0.05$) differences. Lower feed conversion ratio in experimental treatments shows that addition of garlic, black pepper and hot red pepper and their mixture have positive influence on feed utilization and efficiency. From table 2 also can be seen that the highest mortality rate of 5.1% was recorded in the control treatment, while the mortality rate of 0.0% was recorded in treatment T8 with statistically significant ($p<0.05$) differences in compare to treatment T1. From the results given in table 3 it can be seen that the addition of spice

herbs have statistically significant ($p<0.05$) influence on all observed parameters of broiler chickens carcass characteristics.

Table 2. Performance of broiler chickens fed diets containing supplementary spice

Experimental treatments		Parameters			
		Initial live weight, g	Final live weight, g	Total feed conversion ratio, kg/kg	Mortality, %
T1	LSM	388.6^{a}	2075.8^{d}	2.1^{a}	5.1^{a}
T2	LSM	389.7^{a}	2371.1^{b}	1.8^{a}	3.2^{ab}
T3	LSM	386.4^{a}	2336.1^{bc}	1.9^{a}	1.3^{bc}
T4	LSM	384.2^{a}	2076.5^{d}	1.9^{a}	1.3^{bc}
T5	LSM	386.6^{a}	2077.8^{d}	1.8^{a}	0.6^{bc}
T6	LSM	385.3^{a}	2460.6^{a}	1.9^{a}	2.6^{ac}
T7	LSM	385.1^{a}	2442.4^{a}	1.9^{a}	2.6^{ac}
T8	LSM	384.9^{a}	2297.8^{c}	1.9^{a}	0.0^{c}
Pooled SE_{LSM}		3.81	23.78	0.15	0.96

Treatments with different letter indexes in the same column are statistically significantly different ($p<0.05$)

The highest live body weight prior to slaughter and after slaughtering and cooling was observed in chicken in treatments T6 (2448.1 g; 1950.7 g) and T7 (2446.8 g; 1957.1 g) with statistically significant differences in compare to control treatment of chicken T1 (2120.0 g; 1746.2 g). When it's come to a carcass which was ready for roasting, highest yield was recorded in dietary treatment T7 (1829.8 g) which was statistically significant ($p<0.05$) higher compared to treatments T1 (1626.5 g), T3 (1710.7 g), T4 (1532.2 g) and T5 (1587.5 g), respectively. Dressing percentage for carcass ready for roasting ranged from 76.6% in treatment T1 to 73.2% in treatment T4.

Table 3. Carcass characteristics of broiler chickens fed with dietary spices addition

Experimental treatments		Parameters					
		Live weight, g	Weight after slaughtering and cooling, g	Ready for roasting, g	Dressing, %	Ready to grill, g	Dressing, %
T1	LSM	2120.0^{b}	1746.2^{bc}	1626.5^{cd}	76.6^{a}	1425.2^{cd}	67.2^{ab}
T2	LSM	2363.7^{a}	1906.2^{a}	1776.0^{ab}	75.0b^{c}	1592.3^{ab}	67.2^{ab}
T3	LSM	2333.1^{a}	1835.1^{ab}	1710.7^{bc}	73.3^{de}	1518.2^{bc}	65.1^{cd}
T4	LSM	2092.5^{b}	1649.8^{c}	1532.2^{d}	73.2^{e}	1351.7^{d}	64.6^{d}
T5	LSM	2080.6^{b}	1706.0^{c}	1587.5^{d}	76.2^{ab}	1418.8^{cd}	68.1^{a}
T6	LSM	2448.1^{a}	1950.7^{a}	1826.0^{ab}	74.6^{cd}	1621.1^{a}	66.2^{bcd}
T7	LSM	2446.8^{a}	1957.1^{a}	1829.8^{a}	74.7^{bde}	1631.0^{a}	66.6^{acb}
T8	LSM	2360.0^{a}	1894.8^{a}	1768.0^{ab}	74.9^{bcd}	1564.7^{ab}	66.3^{bc}
Pooled SE_{LSM}		51.95	45.34	40.77	0.55	36.12	0.59

Treatments with different letter indexes in the same column are statistically significantly different ($p<0.05$)

Addition of hot red pepper in amount of 1.0 g/100g led to statistically significant ($p<0.05$) weight of carcass ready to grill (1631.0 g) compared to a treatments with the addition of 1.0 g/100g garlic powder (1518.2 g), black pepper powder in both levels

addition (1351.7 g and 1418.8 g) and also compared to a control treatment T1 (1425.2 g). The highest dressing percentage of 67.2% was recorded in treatment with addition of 0.5 g/100g and in control treatment.

Obvious influence of dietary spice addition was recorded in weight of carcass primal cuts (Table 4). Addition of garlic, hot red pepper and mixture of spices let to statistically significant ($p<0.05$) differences in weight of breast meat, compared to control and black pepper powder treatments, but without significant ($p>0.05$) differences between themselves. The primal cuts of the most economically important values such as drumsticks with thighs had the highest weights in treatments T7 (530.7 g), T6 (525.2 g), T2 (520.2 g) and T8 (497.1 g), with statistically significant differences ($p<0.05$) compared to treatments T4, T5 and T1 (438.5 g, 448.7 g and 461.1 g). Weight of wings ranged between 197.6 g (T7) to 160.8 g (T4), back 349.0 g (T7) to 301.3 g (T1), while the similar tendency was observed when it comes to head, neck and legs.

Table 4. Weights of carcass primal cuts, g

Experimental treatments		Parameters						
		Breast	Drumsticks with thighs	Wings	Back	Head	Neck	Legs
T1	LSM	482.2^{c}	461.1^{bc}	180.5^{bc}	301.3^{cd}	44.3^{ab}	76.7^{cd}	75.8^{a}
T2	LSM	550.2^{a}	520.2^{a}	187.6^{ab}	334.2^{acb}	46.1^{a}	81.8^{bc}	84.1^{a}
T3	LSM	533.0^{ab}	478.2^{bc}	174.8^{bc}	332.1^{acb}	43.8^{ab}	75.1^{cd}	80.5^{a}
T4	LSM	467.2^{c}	438.5^{c}	160.8^{d}	285.1^{d}	40.8^{bc}	71.5^{d}	76.7^{a}
T5	LSM	491.1^{bc}	448.7^{c}	173.0^{cd}	306.0^{bdc}	39.3^{c}	71.8^{d}	79.1^{a}
T6	LSM	567.8^{a}	525.2^{a}	186.0^{abc}	342.0^{ab}	43.2^{abc}	90.3^{a}	81.5^{a}
T7	LSM	553.6^{a}	530.7^{a}	197.6^{a}	349.0^{a}	43.7^{ab}	81.2^{bc}	88.5^{a}
T8	LSM	554.0^{a}	497.1^{ab}	183.2^{bc}	330.3^{acb}	44.3^{ab}	86.7^{ab}	82.5^{a}
Pooled SE_{LSM}		17.43	14.74	4.81	12.71	1.54	3.06	5.05

Treatments with different letter indexes in the same column are statistically significantly different ($p<0.05$)

Addition of black pepper powder in amount of 1.0 g/100g led to significantly ($p<0.05$) lower amount of abdominal fat pad in carcass (9.0 g) while the highest concentration of abdominal fat was recorded in control treatment (19.2 g), followed by treatments T7 (17.2 g), T3 (17.0 g), T2 (15.1 g), T8 (13.7 g), T6 (12.8 g) and T4 (11.8 g), respectively. All treatments recorded highest weight of spleen (3.7 – 3.0 g) compared to control treatment (2.2 g), which is one good indicator of chicken better health status. Liver as a main target organ for the studies of xenobiotics and the main "cleaning factory" in the organism was largest in treatments T3, T6 (66.0 g), and the smallest in treatments T5 and T1 (50.6 and 52.3 g). Average weight of gizzards and hearts ranged from 60.2 g (T1) to 32.8 g (T5) and 10.6 g (T3) to 8.6 g (T4). According to our assumptions, addition of spice herbs such as garlic, black pepper and hot red pepper significantly ($p<0.05$) influenced on production parameters and carcass quality of broiler chickens. Results in this study is in agreement with investigation of Fayed et al. (2011) which showed that the dietary addition of garlic in amount of 0.5 kg/t to broiler chickens nutrition led to increased final body weights, which is also in agreement with the findings of Onibi et al. (2009) with the other type of poultry. Our study has also shown that the addition of garlic, black pepper and hot red pepper has positive effect on production results of

chickens, which is also in agreement with previous findings of Ashayerizadeh et al. (2009) with the use of garlic, black cumin and wild mint; Fadlalla et al. (2010), Stanaćev et al. (2011), Issa and Abo Omar (2012) and Puvača et al. (2014) with the use of garlic powder; Al-Kassie et al. (2011) with the use of black pepper and Valiollahi et al. (2013) with the use of black pepper and ginger in broiler chicken nutrition.

Table 5. Weights of the edible offal's and abdominal fat pad, g

Experimental treatments		Parameters				
		Liver	Gizzard	Spleen	Hearth	Abdominal fat
T1	LSM	52.3^{cd}	60.2^{a}	2.2^{b}	9.6^{ab}	19.2^{a}
T2	LSM	54.7^{cd}	34.3^{bc}	3.5^{a}	9.8^{ab}	15.1^{abc}
T3	LSM	66.0^{a}	37.5^{bc}	3.2^{a}	10.6^{a}	17.0^{ab}
T4	LSM	54.5^{cd}	42.1^{bc}	3.7^{a}	8.6^{b}	11.8^{bc}
T5	LSM	50.6^{d}	32.8^{c}	3.0^{ab}	10.2^{ab}	9.0^{c}
T6	LSM	66.0^{a}	34.7^{bc}	3.2^{a}	10.5^{a}	12.8^{abc}
T7	LSM	63.8^{ab}	40.1^{bc}	3.3^{a}	10.2^{ab}	17.2^{ab}
T8	LSM	57.6^{bc}	45.1^{b}	3.3^{a}	10.3^{ab}	13.7^{abc}
Pooled SE_{LSM}		2.38	3.85	0.29	0.62	2.26

Treatments with different letter indexes in the same column are statistically significantly different ($p<0.05$)

As in ours study, the investigation of Khalafalla et al. (2011) showed positive of phytogenic feed additives in quality of broiler carcasses. The same authors have find that the dietary addition of garlic, onion and hot red pepper also have influenced on decreasing of pH of meat in broilers. Nasir and Grashorn (2010) confirmed positively significant effects of the addition of two aromatic plants in broiler nutrition on weight gain, average daily weight gain, feed conversion ratio and abdominal fat percentage. Significant influence was observed in regard to carcass yield, breast percentage, crude protein contents, grill losses and cooking losses. In opposite to investigation of Nasir and Grashorn (2010) and to ours study, Amouzmehr et al. (2012) showed that supplementation of garlic extracts in amount of 3.0 and 6.0% did not affect carcass characteristics including carcass yield, breast, thigh and abdominal fat. The effect of feeding broiler chicks on diets containing different levels of black pepper as natural feed additive on carcass characteristics were studied by Tazi et al. (2014), with the results which indicated that group supplemented with 1.0% of black pepper had significantly ($p<0.05$) heaviest values for body weight gain, feed intake, dressing, best feed conversion ratio, and commercial cuts percentages such as breast, drumstick and thigh. Shahverdi et al. (2013) stated that, drumstick and breast percentages were increased significantly ($p<0.05$) for broilers fed on black pepper at level of 0.02% in the diet. Puvača et al. (2014) reported significant influence of hot red pepper to the dressing percentage which has ranged from 72.0% in control group to 74.3% in group with addition 0.75% of pepper. Fayed et al. (2011) reported significant difference between the average dressing percentages, while this difference was not significant for giblet weight (heart, gizzard, and liver) of the broilers fed rations with or without supplementation of garlic. In research of Tazi et al. (2014) mortality rate and the percentages of edible giblets (liver, heart and gizzard) were not affected significantly ($p>0.05$) by the addition of the black pepper on broiler diets. Broiler chicken fed on

black pepper diets in current study produced the lowest abdominal fat pad percentage, while those fed the control diet produced the highest percentage. This result was in agreement with the findings of Ghaedi et al. (2013) who found that, the use of black pepper extract in broiler water (2 mg/ml) reduced significantly ($p<0.05$) abdominal fat percentage. The result coincided with the finding of Shahverdi et al. (2013) who reported that, inclusion of black pepper in broilers diet (0.02%) significantly reduced abdominal fat percentage. Influence of hot red pepper in amount of 0.25 – 1.0% did not show significant effect when the mass of heart is in question, while the significant differences was observed in share of liver and gizzard.

CONCLUSIONS

Based on the obtained results, it can be concluded with certainty that the addition of garlic, black pepper and hot red pepper in broiler chicken nutrition has positive effect on production performances and chicken carcass quality. Addition of herbs has led to the increase of final body weights, lower feed conversion ratio and higher feed utilization and decrease of chicken mortality. It can also be concluded that significant increase in weight of carcass after slaughtering and cooling and carcass ready for roasting with favourable dressing percentages was influenced by these spice herbs supplementation in broiler diet, which indicates that garlic, black pepper and hot red pepper is effective in altering the chicken body conformation. Addition of spice herbs also has led to increase share of economically important parts of chicken carcass such as breasts and drumsticks with thighs. Therefore the general conclusion would be that the addition of these spice herbs has positive influence on chicken production and carcass confirmation. Recommendation for further investigation should be addressed to determination of spice effect in chicken nutrition on nutritive and sensory characteristic of meat, as well as the influence on lipid oxidation, cholesterol content and fatty acid composition because the nowadays chicken meat is the most used food in human daily consumption.

ACKNOWLEDGEMENTS

This paper is a part of the project III 46012 which is financed by Ministry for Education, science and technological development of the Republic of Serbia.

REFERENCES

ABOU-ELKHAIR, R., AHMED, H.A. and SELIM, S. (2014) Effects of black pepper (*Piper nigrum*), turmeric powder (*Curcuma longa*) and coriander seeds (*Coriandrum sativum*) and their combinations as feed additives on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens. *Asian-Australasian Journal of Animal Sciences,* **27**: 847-854.

AL-KASSIE, G.A.M., AL-NASRAWI, M.A.M. and AJEENA, S.J. (2011) Use of black pepper (*Piper nigrum*) as feed additive in broilers diet. *Research Opinions in Animal & Veterinary Sciences,* **1**: 169-173.

AMOOZ MEHR, A. and DASTAR, B. (2009) Effects of alcoholic extract of two herbs (garlic and thymus) on the performance and blood lipids of broiler chickens. *Journal of Agricultural Science and Natural Resources,* **16**: 61-72.

AMOUZMEHR, A., DASTAR, B., GHASSEMI, NEJAD, J., SUNG, K.I., LOHAKARE, J., FORGHANI, F. (2012) Effects of garlic and thyme extracts on growth performance and carcass characteristics of broiler chicks. *Journal of Animal Science and Technology,* **54(3)**: 185-190.

ASHAYERIZADEH, O., DASTAR, B., SHAMS, SHARGH, M., ASHAYERIZADEH, A., RAHMATNEJAD, E. and HOSSAINI, S.M.R. (2009) Use of garlic (*Allium sativum*), black cumin seeds (*Nigella sativa* L.) and wild mint (*Mentha longifolia*) in broiler chickens diets. *Journal of Animal and Veterinary Advances,* **8**: 1860-1863.

DONOGHUE, D.J. (2003) Antibiotic residues in poultry tissues and eggs: Human health concerns? *Poultry Science,* **82(4):** 618-621.

FADLALLA, I.M.T., MOHAMMED, B.H. and BAKHIET, A.O. (2010) Effect of feeding garlic on the performance and immunity of broilers. *Asian Journal of Poultry Science,* **4:** 182-189.

FAYED, R.H., RAZEK, A. and JEHAN, M. (2011) Effect of dietary garlic supplementation on performance, carcass traits, and meat quality in broiler chickens. Proceedings of the 15th International Congress of the International Society for Animal Hygiene, Vienna, pp. 471-474.

GARDZIELEWSKA, J., PUDYSZAK, K., MAJEWSKA, T., JAKUBOWSKA, M. and POMIANOWSKI, J. (2003) Effect of plant supplemented feeding on fresh and frozen storage quality of broiler chicken meat. *Electronic Journal of Polish Agricultural Universities,* **6**: 23-26.

GHAEDI, H., NASR, J., KHEIR, F., MIRI, Y. and RAHIMIAN, Y. (2013) Effect of use virginiamycin as probiotic, black pepper extract as phytogenic feed additive on performance of broiler chicks. *The Journal of Agricultural Science,* **3(12)**: 521-525.

ISSA, K.J. and ABO OMAR, J.M. (2012) Effect of garlic powder on performance and lipid profile of broilers. *Open Journal of Animal Sciences,* **2**: 62-68.

KHALAFALLA, F.A., FATMA, H.M., DALIA, A., ZAHRAN, A. and MOSA, A.M.M.A. (2011) Influence of feed additives in quality of broiler carcasses. *Journal of World's Poultry Research,* **2(3)**: 40-47.

KOSTADINOVIĆ, LJ., LEVIĆ, J., POPOVIĆ, S., ČABARKAPA, I., PUVAČA, N., ĐURAGIĆ, O. and KORMANJOŠ, Š. (2015) Dietary inclusion of *Artemisia absinthium* for management of growth performance, antioxidative status and quality of poultry meat. *European Poultry Science,* **79**: 1-10.

LI, W.J., ZHAO, G.P., CHEN, J.L., ZHENG, M.Q. and WEN, J. (2009) Influence of dietary vitamin E supplementation on meat quality traits and gene expression related to lipid metabolism in the Beijing-you chicken. *British Poultry Science,* **50**: 188–198.

MANSOUB, N.H. (2011) Comparative effects of using garlic as probiotic on performance and serum composition of broiler chickens. *Annals of Biological Research,* **2**: 486-490.

NASIR, Z. and GRASHORN, M.A. (2010) Effects of *Echinacea purpurea* and *Nigella sativa* supplementation on broiler performance, carcass and meat quality. *Journal of Animal and Feed Sciences,* **19**: 94–104.

ONIBI, G.E., OLUWATOYIN, E., ADEBISI, A., FAJEMISIN, N., AYODE, V. and ADETUN, J.I. (2009) Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. *African Journal of Agricultural Research,* **4(5)**: 511-517.

PRADEEP, C.R. and KUTTAN, G. (2004) Piperine is a potent inhibitor of nuclear factor‐kB (NF‐kB), c‐Fos, CREB, ATF‐2 and pro‐inflammatory cytokine gene expression in B16F‐10 melanoma cells. *International Immunopharmacology,* **4**: 1795‐1803.

POPOVIĆ, S., KOSTADINOVIĆ, LJ., ĐURAGIĆ, O., AĆIMOVIĆ, M., ČABARKAPA, I., PUVAČA, N. and LJUBOJEVIĆ PELIĆ, D. (2018) Influence of medicinal plants mixtures (*Artemisia absinthium, Thymus vulgaris, Menthae piperitae* and *Thymus serpyllum*) in broilers nutrition on biochemical blood status. *Journal of Agronomy, Technology and Engineering Management,* **1(1)**: 91-98.

PUVAČA, N., KOSTADINOVIĆ, LJ., LJUBOJEVIĆ, D., LUKAČ, D., LEVIĆ, J., POPOVIĆ, S., NOVAKOV, N., VIDOVIĆ, B. and ĐURAGIĆ, O. (2015) Effect of garlic, black pepper and hot red pepper on productive performances and blood lipid profile of broiler chickens. *European Poultry Science,* **79**: 1-13.

PUVAČA, N., KOSTADINOVIĆ, LJ., LJUBOJEVIĆ, D., LUKAČ, D., POPOVIĆ, S., DOKMANOVIĆ, B. and STANAĆEV, V.S. (2014) Effects of dietary garlic addition on productive performance and blood lipid profile of broiler chickens. *Biotechnology in Animal Husbandry,* **30(4)**: 669-677.

PUVAČA, N., STANAĆEV, V., GLAMOČIĆ, D., LEVIĆ, J., PERIĆ, L., STANAĆEV, V.Ž. and MILIĆ, D. (2013) Beneficial effects of phytoadditives in broiler nutrition. *World's Poultry Science Journal,* **69(1)**: 27-34.

PUVAČA, N. and STANAĆEV, V. (2011) Selenium in poultry nutrition and its effect on meat quality. *World's Poultry Science Journal,* **67(3)**: 479-484.

SARICA, S., CIFTCI, A., DEMIR, E., KILINC, K. and YILDIRIM, Y. (2005) Use of antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat based broiler diets. *South African Journal of Animal Science,* **35**: 61-72.

SCHWARZ, S., KEHRENBERG, C. and WALSH, T.R. (2001) Use of antimicrobial agents in veterinary medicine and food animal production. *International Journal of Antimicrobial Agents,* **17**: 431-437.

SHAHVERDI, A., KHEIRI, F., FAGHANI, M., RAHIMIAN, Y. and RAFIEE, A. (2013) The effect of use red pepper (*Capsicum annum* L.) and black pepper (*Piper nigrum* L.) on performance and hematological parameters of broiler chicks. *European Journal of Zoological Research,* **2(6)**: 44-48.

STANAĆEV, V., GLAMOČIĆ, D., MILOŠEVIĆ, N., PUVAČA, N., STANAĆEV, V. and PLAVŠA, N. (2011) Effect of garlic (*Allium sativum* L.) in fattening chicks nutrition. *African Journal of Agricultural Research,* **6**: 943-948.

TAZI, S.M.E., MUKHTAR, M.A., MOHAMED, K. and TABIDI, M.H. (2014) Effect of using black pepper as natural feed additive on performance and carcass quality of broiler chicks. *International Journal of Pharmaceutical Research and Analysis,* **4**: 108-113.

VALIOLLAHI, M.R., RAHIMIAN, Y., MIRI, Y. and RAFIEE, A. (2013) Effect use ginger (*Zingiber officinale*), black pepper (*Piper nigrum* L.) powders on performance, some blood parameters and antibody titer against new castle vaccine on broiler chicks. *The Journal of Agricultural Science,* **3**: 535-540.