Review paper

BLACK PEPPER (*Piper nigrum* L.) AND HOT RED PEPPER (*Capsicum annum* L.) IN BROILER CHICKEN NUTRITION

Puvača N.[1], Stanaćev V.[1], Beuković M.[1], Ljubojević, D.[2], Kostadinović Lj.[3], Teodosin S..*

[1]University of Novi Sad, Faculty of Agriculture, Department of Animal Science, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia.
[2]Scientific Institute of Veterinary Medicine "Novi Sad", Rumenački put 20, 21000 Novi Sad, Serbia.
[3]University of Novi Sad, Institute of Food Technology, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia.
*Corresponding author: nikola.puvaca@stocarstvo.edu.rs

Abstract

Antibiotics have been widely used in animal production for decades in past. Although some are used therapeutically to improve the health and well-being of animals, most were given for prophylactic purposes and to improve growth rate and feed conversion ratio efficiency. After the ban of nutritive antibiotic usage in animal nutrition in the European Union, many alternative substances have been investigated for growth promoter potential as their replacement. A large number of experiments have confirmed a wide range of activities of phytoadditives such as black pepper (*Piper nigrum* L.) and hot red pepper (*Capsicum annum* L.) in poultry nutrition for feed intake stimulation, antimicrobial, antioxidative, anticoccidiostatic effects. Besides these effects, black pepper and hot red pepper also have a strong influence on lowering the cholesterol level in edible tissuses as well as on reducing deposition of abdominal fat in carcass. The aim of this review is to present characteristics and effects of phytoadditives, especially black pepper and hot red pepper and their bioactive components in broiler chicken nutrition.

Key words: *black pepper, chickens, nutrition, phytoadditives, red pepper*

Introduction

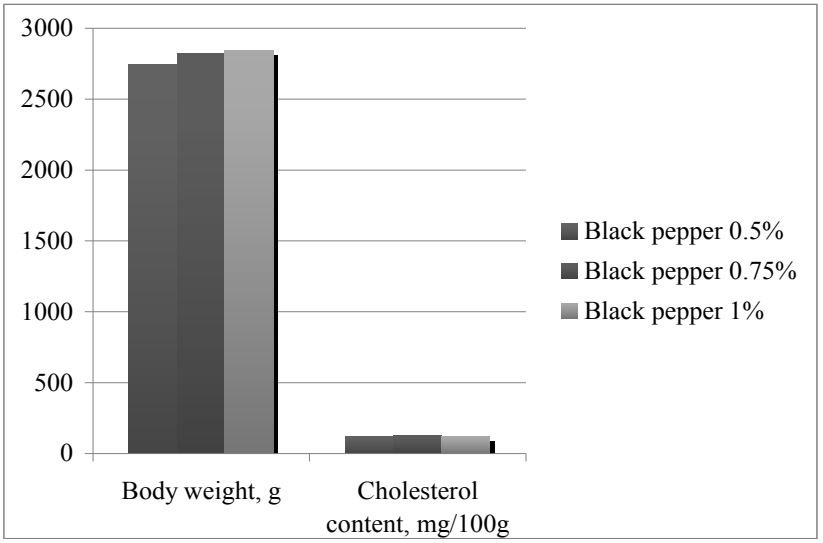
Antibiotics have been widely used in animal production for decades. Although some are used therapeutically to improve the health and well-being of animals, most were given for prophylactic purposes and to improve growth rate and feed conversion ratio efficiency. However, due to the emergence of microbes resistant to antibiotics which are used to treat human and animal infections, the European Commission has banned the use of antibiotics as growth promoters in animal feed. In many countries and in Serbia as well, consumer pressure is pushing the poultry industry to rear animals without antibiotics as growth promoters (Dibner and Richards, 2005; Castanon, 2007). The removal of antibiotics as growth promoters has led to animal performance problems, feed conversion ratio increase and a rise in the incidence of certain animal diseases (Wierup, 2001). The alternatives to antibiotics as growth stimulators are numerous, amounting to finding an adequate non-pharmacological products from the group of prebiotics, probiotics, organic acids, essential oils, medicinal plants or parts of plants such as thyme, basil, oregano, pepper and plenty of others (Simon, 2005; Kostadinović and Lević, 2012; Puvača et al., 2013). Black pepper

(*Piper nigrum* L.) is a flowering vine of Piperaceae family and has been a prized spice in many cultures all over the world. This herb is a known spice which improves digestibility (Moorthy et al., 2009). It is a common medicinal herb used in human diet. The volatile oil of pepper has been shown to have antimicrobial activity (Dorman and Deans, 2000). Black pepper has many medicinal properties for treatment of vertigo, asthma, indigestion, congestion, fever, paralytic, diarrhoea (Ravindran, 2000; Turner, 2004). When used in broiler chicken nutrition it has been found that very small addition of black pepper in the diet, about 0.5 to 1.0%, significantly reduces cholesterol levels in meat (Al-Kassie et al., 2011). Hot red pepper (*Capsicum annum* L.) is one of the most important herbs widely used in human nutrition. Besides its pungent effect, in poultry nutrition it is added in small amounts between 0.25 and 1.0% because it plays an important role in increasing the ability analyser and deposition of cholesterol and fat in the body and contributes to decrease levels of triglycerides and works to support the vascular system in the body. Hot red pepper is also rich in vitamin C which has a considerable impact on improving production through contributing the reduction of heat stress taking into account that poultry consumption of hot red pepper induces a considerable change in energy balance (Yoshioka et al., 2001; Al-Kassie et al., 2012). The aim of this paper is to present the effects of herbal plants such as black pepper and hot red pepper in poultry nutrition as a phytobiotics and possible alternative to antibiotics.

Black pepper (*Piper nigrum* L.) in broiler chicken diets

Black pepper is known as spice due to its pungent quality. Black pepper is a flowering vine in the family Piperaceae, genus piper and species *piper nigrum*. Black pepper is found to improve digestibility (Moorthyet et al., 2009). Pepper efficiency compounds consist of cupsaeesin, cupsisin and cupsantine and some of them can allay rheumatic aches. Piperine is one of the compounds of black pepper which has antiache effect (Mahadyet al., 2008). In addition, the bioactive molecule, piperine, present in pepper, has a major pharmacological impact on nervous and neuromuscular system and it can help in digestion (Great, 2003). Black pepper was found to be rich in glutathione peroxidase and glucose-6-phosphate dehydrogenase while it has been shown that piperine can dramatically increase absorption of selenium, vitamin B complex, beta carotene and curcumin as well as other nutrients (Khalafet et al., 2008; Taziet et al., 2014). Piperine enhances the thermogenesis of lipid and accelerates energy metabolism in the body and also increases the serotonin and β-endorphin production in the brain (Al-Kassieet et al., 2011). Pepper has been found to have antioxidant properties and anticarcinogenic effect, especially when compared to chilli (Naliniet al., 2006). The outer fruit layer contains important odour contributing terpenes, including pinene, sabinene and limonene which give tasty properties. The consumption of these spices exerts several health beneficial effects by the virtue of their innumerable therapeutic potentials in fever, asthma, cold, cough and other general health disorders (Rakesh and Sushil, 2003). Phytogenic feed additives are plant derived products used in animal feeding to improve the performance of agricultural livestock and may satisfy the increasing concerns of consumers, since they prove to be safe and effective. Piperine (1-piperoyl-piperidine) is a major alkaloid component of black pepper (*Piper nigrum* L.) and is responsible for its pungent and biting taste (Dograet et al., 2004). Among its chemical and biological activities, piperine exhibits antimicrobial (Reddy et al., 2004), anti-inflammatory (Pradeep and Kuttan, 2004) and antioxidant (Mittal and Gupta, 2000) properties. It also increases the bioavailability of certain drugs in the organism (Karan et al., 1999) and acts as a chemo preventive factor (Reenet et al., 1997). According to Kohlertet et al. (2000), the active principles of phytogenic additives are absorbed in the

intestine by enterocytes and are quickly metabolized by the body. Piperine induces alterations in membrane dynamics and permeation characteristics, as well as the synthesis of proteins associated with cytoskeletal function, resulting in an increase in the small intestine absorptive surface (Khajuriaet et al., 2002). The rapid metabolism and the shortlife of piperine indicate a low risk of accumulation in the tissue. Cardoso et al. (2009), while working on broiler chickens, found that orally administered piperine did not interfere in weight gain or liver relative weight. However, liver hystopathological changes were observed in a dose dependent manner, indicating that 1.0 mg/kg of piperine, with oral route of administration, is nontoxic for broiler chickens, as previously reported for rats and mice (Dograet et al., 2004; Gaginiet et al., 2010). The effect of feeding broiler chicks on diets containing different levels of black pepper as natural feed additive on productive performance, carcass characteristics and economic efficiency were studied by Taziet et al. (2014). A total of one hundred and sixty, one day old broiler chicks were randomly divided into four experimental groups. Each group was further subdivided into five replicates at the rate of eight chicks per pen in a complete randomized design. The chicks were fed on two basal diets. The black pepper was added to the basal diets at several levels (0.0, 0.5, 0.75 and 1%). The experimental diets were fed for six weeks duration. The result indicated that the group supplemented with black pepper in amount of 1% had significantly ($P<0.05$) highest values for body weight gain, feed intake, dressing, improved feed conversion ratio, and commercial cuts percentages (breast, drumstick and thigh). The birds fed on the control group produced significantly ($P<0.05$) highest abdominal fat percentage. The 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 in broiler diets. Birds fed on the highest level of black pepper (1%) yielded the highest net profit as compared to other experimental groups. A study was also conducted by Al-Kassieet et al. (2011) to determine the performance of broilers fed diets with black pepper. A total of 250 one day old chicks were used. Four levels of black pepper at the rate of 0.25%, 0.50%, 0.75% and 1% were incorporated into the basal diet of broilers for six weeks. The results revealed that the inclusion of black pepper at the levels of 0.50%, 0.75% and 1% in the diets improved body weight gain, feed intake and conversion ratio. At the same time the black pepper of 0.50 %, 0.75% and 1% depressed the cholesterol ratio concentration. It was concluded that the use of black pepper as feed additive at 0.50%, 0.75% and 1% enhanced the overall performance of broiler chicks. Graph 1 shows the effect of different levels of black pepper powder on final body weight of chickens and total cholesterol levels in tissues. Besides being a natural compound that does not produce detected residues in the animal or in their derived products, piperine is easily isolated in great amounts and has shown interesting biological effects in studies on animals.



Graph.1. *Final body weight of chickens fed with black pepper powder and total cholesterol levels in tissues (Al-Kassieet et al., 2011; Akbarinet et al., 2012; Valiollahiet et al., 2013).*

Hot red pepper (*Capsicum annum* L.) in broiler nutrition

It has been proven that some of the phytobiotic components have different active substances (Al-Kassie and Witwit, 2010). In spite of that the poultry do not sense the effect of hot spice, because of the lack of the receptors specific to capsaicin binding (Mason and Maruniak, 1983; Geisthovel et al., 1986), or they have receptors that are insensitive to capsaicin (Szolcsangi, 1976), but it increases the appetite that the addition of hot red pepper to the diet influence on the feed consumption of broilers (Yoshioka et al., 1999). A recent study involved in the poultry performance showed that blends of active compounds of hot red pepper can cause chemo preventive and chemotherapeutic effects. As for hot red pepper the capsaicin is the main active compound responsible for the pungent effects of various species of hot pepper (Jancso et al., 1997) and the main component of hot red pepper including hot taste, capsaicin has been shown to have a protective function in the gastric mucosa as a stimulant of afferent nerve endings. Hot red pepper plays an important role in increasing the ability analyser and deposition of cholesterol and fat in the body and contributes to decreasing levels of triglycerides and acts to support the vascular system in the body. Hencken, (1991) explained that hot red pepper is rich in vitamin C which has a considerable impact on improving production through contributing the reduction of heat stress taking into account that birds consumption of hot red pepper induces a considerable change in energy balance when individuals are given free access to feed (Yoshioka et al., 2001). Although it is well known that plant extracts improve the digestibility of the feeds in broilers, Hernandez et al. (2004) revealed that the effect of different additives on digestibility has slightly improved performance and the differences were not significant. Capsinoids are a family of compounds that are analogues of capsaicin, which is the pungent component in hot red peppers. Capsinoids are widely present at low levels in red pepper fruit, they include capsiate, dihydrocapsiate and have a very favourable safety profile (Kobata et al., 1999). Hot red pepper is known as the herb crucial for stimulating the healing effects of the body organs such as kidney, lungs, stomach and heart. Al-Kassie

et al. (2012) conducted the study to investigate the efficiency of utilization of feed mixture supplemented with hot red pepper to broiler on its productive performance and some haematological traits. A total of 300 one day old chicks were divided into five groups of 60 birds each and were allocated to five feeding treatments, a control group free from any additions, and groups with addition of 0.25, 0.5, 0.75 and 1 % of hot red pepper respectively. The results showed a highly significant ($P<0.05$) average in (live weight gain, feed consumption, feed conversion ratio and dressing percent) with no significant difference in the edible giblet. At the same time the above mixture with addition of 0.75 and 1.0% of hot red pepper depressed the cholesterol ratio concentration. It was concluded that using a mixture as feed additive at levels 0.75 and 1 % enhanced the overall performance of broiler chicks, and improved haematological traits. Shahverdi et al. (2013) conducted the study with objective to determine the effect of the use of red pepper, black pepper and their mixture powder on performance of broiler chicks. Chicks were fed basal diet as control, 0.02% red pepper, 0.02% black pepper and with the mixture of these two powders. Feed intake, body weight gain and feed conversion ratio were determined. Cholesterol, triglyceride, glucose levels and antibody titter against new castle vaccine were investigated. The results revealed that the inclusion of red and black pepper in broiler diet improved body weight gain, feed intake and conversion ratio. In addition, the use of red and black pepper depressed the cholesterol, triglyceride and glucose concentration and decreased H/L ratio concentration in broiler blood plasma ($P<0.05$). Data from the study showed that the use of red and black pepper powder on broiler diets can cause increase in total diameter of small intestine parts ($P<0.05$). It was concluded that the use of red and black pepper as feed additive at 1% enhanced the overall performance of broiler chicks.

Conclusion

Based on the available data it can be concluded that phytobiotics can be used as natural non-antibiotic growth promoters in broiler nutrition. The efficacy of phytobiotic applications in poultry depends on many factors. The most important consideration seems to be the differences in composition of the active components and feed inclusion levels, poultry genetics and overall diet composition. The advancement of knowledge and understanding of the complex poultry gut ecosystem in order to be able to fully explore the precise modes of action of phytogenic compounds represents a clear prerequisite for the design of highly efficacious phytogenic products. From the obtained data and field results it can be concluded that phytobiotics such as black pepper and hot red pepper can be successfully used in poultry nutrition for the improvement of overall productive performances, reduction of cholesterol levels in edible tissues and meat quality improvement. In general, phytobiotics have positive effects but the knowledge of their use in poultry nutrition is still limited and requires further research.

Acknowledgements

This paper is a part of the project III 46012 which is financed by the Ministry for Science and Technological Development of the Republic of Serbia.

References

1. Akbarian A, Golian A, Kermanshahi H, Gilani A and Moradi S 2012. Influence of turmeric rhizome and black pepper on blood constituents and performance of broiler chickens. African Journal of Biotechnology 11, 8606-8611.

2. Al-Kassie GAM and Witwit NM 2010. A comparative study on diet supplementation with a mixture of herbal plants and dandelion as a source of prebiotics on the performance of broilers. Pakistan Journal of Nutrition 9, 67-71.
3. Al-Kassie GAM, Al-Nasrawi MAM and Ajeena SJ 2011. Use of black pepper (*Piper nigrum*) as feed additive in broilers diet. Research Opinions in Animal and Veterinary Sciences 1, 169-173.
4. Al-Kassie GAM, Ghassan Y, Butris SJA and Ajeena J 2012. The potency of feed supplemented mixture of hot red pepper and black pepper on the performance and some hematological blood traits in broiler diet. International Journal of Advanced Biological Research 2, 53-57.
5. Cardoso VS, Lima CAR, Lima MEF, Dorneles LEG, Tei Xeira Filho Wl, Lisboa RS, Guedes Junior DS, Direito GM and Danelli MGM 2009. Administração oral de piperina em frangos de corte. Ciência Rural 39, 1521‑1526.
6. Castanon JIR 2007. History of the use of antibiotic as growth promoters in European poultry feeds. Poultry Science 86, 2466-2471.
7. Dibner JJ and Richards JD 2005. Antibiotic growth promoters in agriculture: History and mode of action. Poultry Science 84, 634-643.
8. Dorman HJ and Deans SG 2000. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. Journal of Applied Microbiology 88, 308-316.
9. Dogra RKS, Khanna S and Shanker R 2004. Immunotoxicological effects of piperine in mice. Toxicology 196, 229-236.
10. Gagini TB, Silva RE, Castro IS, Soares BA, Lima MEF, Brito MF, Mazur, C, Direito GM and Danelli MGM 2010. Oral administration of piperine for the control of aflatoxin intoxication in rats. Brazilian Journal of Microbiology 41, 345‑348.
11. Geisthovel E, Ludwig O and Simon E 1986. Capsaicin fails to produce disturbances of autonomic heat and cold defense in avain species (Anas platy rhynchos). Pflügers Archiv - European Journal of Physiology 406, 343-350.
12. Great H 2003. Plants and plant extracts for improving animal productivity. Proceedings of Nutritional Society 62, 279-290.
13. Hencken H 1991. Cooling the burn from hot peppers. Journal of the American Medical Association 266, 2766.
14. Hernandez F, Madrid J, Garcia V, Orengo J and Megias MD 2004. Influence of two plant extracts on broiler performance digestibility and digestive organ size. Poultry Science 85, 1466-1471.
15. Jancso G, Kiraly E and Jansco-Gabor A 1997. Pharmacologically induced selective degeneration of chemosensitive primary sensory neurons. Nature 270, 741-743.
16. Karan RS, Bhargava VK and Garg SK 1999. Effect of trikatu, an Ayurvedic prescription, on the pharmacokinetic profile of rifampicin in rabbits. Journal of Ethnopharmacology 64, 259‑264.
17. Khalaf AN, Shakya AK, Al-Othman A, El-Agbar Z and Farah H 2008. Antioxident activity of some common plants. Turkish Journal of Biology 32, 51-55.
18. Khajuria A, Thusu N and Zutshi U 2002. Piperine modulates permeability characteristics of intestine by inducing alterations in membrane dynamics: influence on brush border membrane fluidity, ultrastructure and enzyme kinetics. Phytomedicine 9, 224-231.
19. Kobata K, Todo G, Yazawa S, Iwa I and Watab T 1999. Novel capsacicinoid-like subatances, capsiate and dihydrocapsiate, from the fruits of a nonpungent cultivar, CH-19

sweet of pepper (*Capsicum annuum* L.). Journal of Agricultural Food Chemistry 46, 1695-1697.

20. Kostadinović LJ and Lević J 2012. Use of phytogenic products for pig and broiler diseases. Proceedings of 15th International Feed Technology Symposium, Novi Sad, Serbia, pp, 64-74.
21. Mahady, G.B., Pendl, S.L., Yun, G.S., Lu, Z.Z. and Stoia, A. (2008) Ginger (Zingiber officinale) and the gingerols inhibit the growth of Cag A+ strains of Helicobacter pylori. Anticancer Research 23: 3699-3702.
22. Mason JR and Maruniak JA 1983. Behavioral and physiological effects of capsaicin in red winged blackbirds. Pharmacology Biochemistry and Behavior 19, 857-862.
23. Mittal R and Gupta RL 2000. In vitro antioxidant activity of piperine. Methods and Findings in Experimental and Clinical Pharmacology 122, 271-274.
24. Nalini N, Manju Y and Menon V 2006. Effect of spices on lipid metabolism in 1, 2-dimethylhydrazine-induced rat colon carcinogenesis. Journal of Medicinal Food 9, 237-45.
25. Moorthy M, Ravikumar S, Viswanathan K and Edwin SC 2009. Ginger, pepper and curry leaf powder as feed additives in broiler diet. International Journal of Poultry Science 8, 779-782.
26. Pradeep CR 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.
27. Puvača N, Stanaćev V, Glamočić D, Lević J, Perić L, Stanaćev V and Milić D 2013. Beneficial effects of phytoadditives in broiler nutrition. World's Poultry Science Journal 69, 27-34.
28. Rakesh L and Sushil KK 2003. Bronchial asthma in scientific basis for ayurvedic therapies. Analytical Biochem 47, 389-394.
29. Ravindran PN 2000. Black pepper: Piper nigrum series: Medicinal and aromatic plants. Centre for Medicinal Plant Research, Kerala, India.
30. Reddy SV, Srinivas PV, Praveen B, Kishore KH, Raju BC, Murthy US and Rao JM 2004. Antibacterial constituents from the berries of Piper nigrum. Phytomedicine 11, 697‐700.
31. Reen RK, Wiebel FJ and Singh J 1997. Piperine inhibits aflatoxin B1-induced cytotoxicity and genotoxicity in V79 Chinese hamster cells genetically engineered to express rat cytochrome P4502B1. Journal of Ethnopharmacolology 58, 165-173.
32. 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, 44-48.
33. Simon O 2005. Micro-organisms as feed additives-probiotics. Advances in Pork Production 39, 161-167.
34. Szolcsangi J 1976. On the specificity of pain producing and sensory neuron blocking effect of capsaicin. Symposium on Analgesics, Akademiai kiad, Budapest, pp, 167-172.
35. Tazi SME, Mukhtar MA, Mohamed K and Tabidi MH 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.
36. Turner J 2004. Spice: Black pepper and White pepper. The History of a Temptation. London, Vintage Books.

37. Valiollahi MR, Rahimain 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. Scholarly Journal of Agricultural Science 3, 535-540.

38. Yoshioka M, St-Pierre S, Drapeau V, Dionne I, Doucet E, Suzuki M and Tremblay A 1999. Effects of red pepper and caffeine consumption on energy balance in subjects given free access to foods. British Journal of Nutrition 80, 503-510.

39. Yoshioka M, Doucet E, Drapeau V, Dionne I and Tremblay A 2001. Combined effects of red pepper and caffeine consumption on energy balance in subjects given free access to foods. British Journal of Nutrition 85, 203-211.

40. Wierup M 2001. The Swedish experience of the 1986 ban of antimicrobial growth promoters, with special reference to animal health, disease prevention, productivity, and usage of antimicrobials. Microbial Drug Resistance 7, 183–190.