The effect of feed additives in pheasants fattening: A review

Účinok kŕmych aditív vo výkrme bažantov

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Abstract

Fattening pheasants for the production of quality meat is a relatively recent development. With its high protein and low fat content, meat of pheasant is a highly nutritious food whose value exceeds that of broiler chickens meat. Despite the fact that the intensive rearing of pheasants has developed relatively quickly in recent years, information on the fattening capabilities and slaughter values of pheasants is often insufficient in the current literature. The length of the fattening period also differs in the literature and reported from 13 to 20 weeks while highest weight gains of pheasants to occur between 4 and 12 weeks of age. Growth of pheasants is also reflected in the weight and dimensions of internal organs, crop, oesophagus, gizzard and intestine grow up to 12 weeks of age, after which they develop their physiological ability. The structure, weight and length of the digestive tract and other internal organs of pheasants depend on housing system, gender and nutrition. Relatively few investigations were conducted to determine the influence of feed additives on fattening performance of pheasants. One of the possibilities is the use of humic acids in nutrition pheasant. Humic acids are organic compounds naturally present in soil and they positively affected growth ability, feed conversion and reducing mortality.

Keywords: fattening, feed additives, humic acids, pheasant

Abstrakt

Výkrm bažantov na produkciu kvalitného mäsa má relatívne krátku históriu. So svojím vysokým obsahom bielkovín a nízkym obsahom tuku, je mäso bažantov vysoko výživnou potravinou, ktorého hodnota prevyšuje mäso brojlerových kurčiat. Napriek tomu, že intenzívny chov bažantov sa v posledných rokoch relatívne rýchlo vyvíja, odborných informácií o možnostiach výkrmu a jatočnej hodnote bažantov je pomerne málo. Odporúčaná dĺžka výkrmu sa odlišuje aj v literatúre a pohybuje sa od 13 do 20 týždňov, pričom najvyššie prírastky bažantov sa dosahujú medzi 4. a 12.

týždňom veku. Rast bažantov sa odráža aj v hmotnosti a rozmeroch vnútorných orgánov, hrvoľ, pažerák, žalúdok a črevá rastú až 12 týždňov, potom sa rozvíjajú ich fyziologické schopnosti. Štruktúra, hmotnosť a dĺžka tráviaceho traktu a vnútorných orgánov bažantov závisí systému chovu, pohlavia a výživy. Relatívne málo experimentov bolo realizovaných za účelom zistenie vplyvu doplnkových látok na výkrmové ukazovatele bažantov. Jednou z možností je použitie humínových kyselín vo výžive výkrmových bažantov. Humínové kyseliny sú organické zlúčeniny prirodzene prítomné v pôde a pozitívne ovplyvňujú rastovú schopnosť, konverziu krmiva a znižujú mortalitu.

Kľúčové slová: bažant, humínové kyseliny, kŕmne aditíva, výkrm

Detailný abstrakt

V poslednom období možno vo svete badať zvýšený záujem o farmový spôsob chovu voľne žijúcej zveri. Je to spôsobené predovšetkým dopytom po mäse a jeho zúžitkovaním v humánnej výžive. Doposiaľ bolo publikovaných niekoľko prác, ktoré sa zaoberajú aj farmovým chovom bažantej zveri. Viaceré práce sa zaoberajú možným výkrmom bažantov, ktorý vychádza z klasického výkrmu brojlerových kurčiat. V relatívne nedávnej dobe sa v rámci umelého chovu bažantov začal uplatňovať aj ich výkrm za účelom produkcie kvalitného bažantieho mäsa, typického vysokým obsahom ľahko stráviteľných bielkovín a nízkym obsahom tuku. Táto situácia už nie je ničím neobvyklá v zahraničí, kde cielene orientované farmy za týmto účelom bažanty intenzívne vykrmujú a celoročne realizujú svoju produkciu na trhu vo forme zmrazeného, ale aj chladeného mäsa. Pri vlastnej realizácii výkrmu bažantov je nutné brať do úvahy viacero faktorov, ktoré môžu významne ovplyvniť jeho úspešnosť. Okrem selekcie vhodných genotypov ide tiež aj o správnu techniku a technológiu výkrmu, kvalitnú výživu v jednotlivých fázach rastu a určenie vhodnej doby porážky. Výživa výkrmových bažantov sa realizuje spravidla sypkými, neskôr granulovanými kompletnými kŕmnymi zmesami, ktorých nutričné zloženie vychádza z výkrmových kŕmnych zmesí pre brojlerové kurčatá. Podľa dostupných informácii v odbornej literatúre je odporúčaná dĺžka výkrmu bažantov od 13 do 20 týždňov veku, pričom najvyššiu intenzitu rastu možno očakávať medzi 4. a 12. týždňom veku. Neskôr sa výkrm javí ako nerentabilný. Vo výžive voľne žijúcej zveri sa čoraz viac uplatňujú rôzne kŕmne aditíva, probiotiká, prebiotiká, fytobiotiká, kŕmne kyseliny, enzýmy, ale aj humínové kyseliny. Ich zaradením do výživy farmovej zveri sa zohľadňujú pozitívne prejavy týchto aditív testované na hospodárskych zvieratách. Probiotiká, prebiotiká a kŕmne enzýmy boli vo svete pomerne dobre popísané z hľadiska ich účinku vo výkrme hydiny. Fytogénne kŕmne aditíva sú považované za pomerne novú skupinu aditív, ktorých účinnými látkami sú rôzne chemické zlúčeniny obsiahnuté v aromatických rastlinách, ich extraktoch a éterických olejoch. Fytobiotiká sa vyznačujú veľmi dobrým baktericídnym, fungicídnym a virocídnym účinkom tak v tráviacej sústave, ako aj v krmive. Pomerne veľký priestor sa venuje aj problematike humínových kyselín. Humínové látky sa zaraďujú medzi prírodné organické zlúčeniny vznikajúce chemickým a biologickým rozkladom organických látok, najmä rastlín a živočíchov. V prírode sa vyskytujú v liečivých bahnách, v ornici, v organických hnojivách, v rašeline, lignite a v hnedom uhlí. Humínové látky majú

vysokú adsorpčnú kapacitu. Viažu na seba mikrobiálne toxíny, mykotoxíny a iné pre organizmus nebezpečné zlúčeniny, napr. amoniak, polychlórované bifenyly, dioxíny a pod., ktoré sa s nimi vylučujú trusom. Vzhľadom na veľký špecificky aktívny povrch zabezpečujú pre organizmus detoxikáciu a hrajú významnú úlohu v profylaxii chorôb, najmä gastrointestinálneho traktu. Vykazujú dobrú pufračnú kapacitu a tak stabilizujú pH v tráviacom trakte.

Introduction

Pheasant meat in particular, typical to the high content of some proteins and the low content of fat that moreover shows a higher proportion of essential fatty acids (FA), is a highly valued food, outdoing even the nutritional value of broiler chicken meat (Straková et al., 2006; Straková et al., 2011; Vitula et al., 2011). There are two main sources of pheasant's meat: hunting and farming (Tucak et al., 2008; Hofbauer et al., 2010). Pheasant meat is characterized by high nutritive value, as evidenced by high protein content of breast (23.5-25.2%) and leg muscles (19.4-22.7%), and low proportion of fat (0.6-1.1%), especially in breast muscles (Večerek et al., 2005; Kuźniacka, et al. 2007). The content of most amino acids in breast and thigh muscles (in relation to dry matter) is higher in pheasants than in broiler chickens (Straková et al., 2006). Meat of pheasant belongs to the culinary delicacy which is supplied to the many restaurants (Shulin and Shen, 1998; Lauková and Kandričáková, 2015).

Pheasants fattening

Fattening pheasants for the production of quality meat is a relatively recent development (Zapletal et al., 2012). With its high protein and low fat content, pheasant is a highly nutritious food whose value exceeds that of broiler chickens (Straková et al., 2011). Despite the fact that the intensive rearing of pheasants has developed relatively quickly in recent years, information on the fattening capabilities and slaughter values of pheasants is often insufficient in the current literature. The length of the fattening period also differs in the literature. Kokoszynski et al. (2011) report 16-20 weeks, and the carcass yield between 69.7 and 73.7%, and similar conclusions were also reached by Adamski and Kuzniacka (2006). However, Sarica et al. (1999) used a shorter fattening period of 13, 14 and 15 weeks with a slaughter yield of 74.19%, 73.13% and 74.3%, respectively. A fattening period of 13 weeks was also used in the work of Straková et al. (2005). Growth traits of young pheasants were investigated by Torgowski et al. (1990), Ricard et al. (1991), Sarica and Karacay (1994), Krystianiak and Torgowski (1998), Tapeli et al. (1999), Strakova et al. (2005), Ipek and Dikmen (2007), Đorđević et al. (2010), Kuźniacka and Adamski (2010). A study by Strakova et al. (2005) showed that pheasants have the highest daily weight gains between 41 and 70 days of age (13 $g*day^{-1}$) and males have significantly higher ($P<0.01$) gains (12 $g*day^{-1}$) than females (9 $g*day^{-1}$) between 1 and 90 days of age. Meanwhile, Ipek and Dikmen (2007) found the highest weight gains of pheasants to occur between 4 and 8 weeks of age. Other research demonstrated that pheasants already reach the final length of lower thigh and shank at 12 weeks of age. Keel length increases longer (to 12-16 weeks), and chest length and circumference to 24 weeks of age (Mroz, 2003). Determination of growth rate is

one of the ways to monitor the growth of pheasants. Using the formula suggested by Brody, it was shown that the growth rate of pheasants was most intensive up to 4 weeks and steadily decreased up to 8 weeks (Mroz, 2003). In Poland, meat pheasants are usually slaughtered at 16-18 weeks of age when the body weight of birds is about 1 kg and has full feathering. In addition, pheasants are characterized by high carcass yield of 69.7-73.7% when slaughtered at the age of 16-20 weeks. Breast muscle content of game pheasant carcasses ranges from 29.2 to 33.2% according to age and is markedly higher than in broiler chickens (20.8-24.5%). The proportion of leg muscles is also high and ranges from 22 to 24.7% in pheasants and from 19.9 to 22.2% in broiler chickens (Adamski and Kuźniacka, 2006; Kokoszyński and Bernacki 2008; Kokoszyński et al., 2008; Gornowicz et al., 2009). Growth of pheasants is also reflected in the weight and dimensions of internal organs. Analysis of the weight of crop, oesophagus, gizzard and intestine showed that they grow up to 12 weeks of age, after which they develop their physiological ability. Reproductive organs of pheasants grow to 24 weeks of age with intensive development in February and March, which precedes the onset of lay (Mroz, 2003). The structure, weight and length of the digestive tract and other internal organs of pheasants depend, among others, on housing system, nutrition and gender (Ricard and Petitjean, 1989; Hell et al., 2003; Marzoni et al., 2005; Baohua et al., 2010; Kokoszyński et al., 2010). Male and female game pheasants evaluated in other studies were characterized by lower body weight at 4, 8, 12, 16 and 20 weeks of age compared to those analysed in the present experiment (Adamski and Kuźniacka, 2006; Ipek and Dikmen, 2007). However, birds evaluated at 20 weeks of age had slightly lower body weight than 17-week-old pheasants kept in aviaries (Ricard et al., 1991). Moreover, as in studies by Ricard et al. (1991), Sarica and Karacay (1994) and Adamski and Kuźniacka (2006), the analysed males were heavier than females. The analysed males and females had longer keel, shorter shanks and generally longer trunk and lower thigh compared to game pheasants investigated by Mroz (2003). Young pheasants show a high rate of growth, but their daily gains vary according to growth period. Ipek and Dikmen (2007) found the highest daily weight gains of pheasants between 4 and 8 weeks, Ricard et al. (1991) and Strakova et al. (2005) between 6 and 10 weeks and Sarica and Karacay (1994) between 7 and 12 weeks of age. The analysed pheasants were characterized by high dressing percentage. However, the percentage of eviscerated carcass with neck in pre-slaughter body weight of the pheasants selected for dissection was lower than in 16th and 20th week old male and female pheasants evaluated by Adamski and Kuźniacka (2006). Likewise, Sarica et al. (1999) and Strakova et al. (2005) obtained higher dressing percentage in younger pheasants than those evaluated in experiment. In the present study, dressing percentage of pheasants did not change with age. Other authors (Sarica et al., 1999; Adamski and Kuźniacka, 2006) observed higher dressing percentage in older pheasants. Like in studies by Strakova et al. (2005) and Adamski and Kuźniacka (2006), males had higher dressing percentage than females. Decreased proportions of neck and wings were found in the carcasses of older pheasants. Earlier studies (Sarica et al., 1999, Adamski and Kuźniacka, 2006) also reported the proportion of wings to decrease in the carcasses of older birds. The proportion of breast muscles in carcasses with neck was higher in pheasants aged 20 weeks compared to 18-week-old birds and higher in males than in females, which is in agreement with the findings of Adamski and Kuźniacka (2006).

Meanwhile, Torgowski et al. (1990) and Strakova et al. (2005) observed that the content of breast muscles was higher in females than in males. In the carcasses of analysed pheasants, the content of leg muscles did not change with age. In another experiment (Adamski and Kuźniacka, 2006), the proportion of leg muscles decreased from 23.9% in 16-week-old pheasants to 23% in 20-week-old birds. The total content of skin with subcutaneous fat in the analysed pheasants was higher in female than in male breeding pheasants evaluated by Tucak et al. (2004). Meanwhile, Adamski and Kuźniacka (2006) found a higher content of skin with subcutaneous fat and abdominal fat in 16- and 20-week-old males and females. The content of abdominal fat in the carcasses of evaluated pheasants was lower (Strakova et al. 2005), similar (Kokoszyński et al. 2008b) or higher (Sarica et al. 1999) than in other experiments. As in earlier studies with broiler chickens, relative lengths of small intestine, caeca (Amerah and Ravindran, 2008; Gabriel et al., 2008) and rectum decreased with age. The significantly greater relative of intestine lengths in females than in males is associated with their greater lengths and with lower body weights of the hens. Percentage of gizzard (ventriculus) in the analysed birds was greater than in pheasants of similar age (males 1.16 and 1.33%, females 1.36%) studied by Ricard and Petitjean (1989). Meanwhile, Kokoszyński et al. (2010) found higher gizzard content in the body of males (1.6%) and the same content in females (1.7%) receiving only feed mixtures at 16 weeks of age as in the analysed birds, whereas Marzoni et al. (2005) reported higher gizzard content in 120-day-old pheasants (control group 1.9%, experimental group 1.8%). The mean values of liver percentage were higher than those reported for pheasants aged about 5 months (males 1.3 and 1.48%, females 1.38%) by Ricard and Petitjean (1989) and for 20-week-old birds (control group 1.65%, caponized group 1.72%) by Severin et al. (2006). Liver content in the analysed females was higher than in males, just as in 16-week-old pheasants fed a diet containing whole wheat grain (Kokoszyński et al. 2010). The heart content in males was similar or the same, and in females lower than in earlier research (Ricard and Petitjean 1989, Kokoszyński et al. 2010), whereas spleen percentage was lower than in breeding pheasants (males 0.11, females 0.12%) of similar age investigated by Hell et al. (2003). Adamski and Kuźniacka (2006) reported pheasant cocks to be significantly heavier than hens in the 12^{th}, 16^{th} and 20^{th} weeks of life. Kuźniacka and Adamski (2010) observed that male pheasants attained significantly higher body weight than females in the 8^{th}, 12^{th}, 16^{th}, 20^{th} and 24^{th} weeks of life, but not in the 3^{rd} one. These authors also have shown that shank length was not sexually dimorphic in weeks 3-24 and forearm length was sexually dimorphic only in weeks 16^{th} and 20^{th}. In the case of other traits (trunk length, breast bone length, chest circumference, chest depth and shank thickness), significant sexual dimorphism was recorded in the 12^{th} or 16^{th} week of life and later periods of measurement (i.e. 20^{th} and 24^{th} week of life). Strakova et al. (2005) reported highest carcass yield in females (71.4%) and males (71.71%) was obtained on the 70^{th} day and the 90^{th} day of fattening, respectively. The results show that pheasant carcass yield (females and males) is as good as in broiler chickens for which carcass yield ranges between 60% and 70% (Lazar, 1990; Novakova, 1991). As with pheasants the carcass yield in broiler chickens also varied with the duration of fattening as observed by Zelenka et al. (1989) in broilers. Ricard et Petitjean (1989) who performed similar experiments in pheasants obtained comparable results reporting the value of 71% for carcass yield. The age of pheasant chicks had a significant effect on the content of all fatty acids.

Significant changes in the proportion of fatty acid groups were recorded mainly at 20, 40 and 60 days of age. By 20 days of age the proportion of monounsaturated fatty acids decreased considerably in relation to the increase in the content of polyunsaturated fatty acids, while the n6/n3 ratio decreased markedly. The content of monounsaturated fatty acids increased between day 20 and day 40, causing a simultaneous decrease in polyunsaturated fatty acids. From day 40, the monounsaturated fatty acid content increased gradually till the end of fattening, whereas the reverse trend was observed in the saturated fatty acid content in this period. As for polyunsaturated fatty acids, their presence increased from day 40 to day 60, followed by a gradual decrease till the end of fattening (Jakešová et al., 2014).

Additives in pheasants fattening

There are many feed additive groups for non-ruminants or birds as a base for pheasants fattening. The oldest feed additives in poultry nutrition and feeding are probiotics, which are tested more than 60 years (Gálik, 2012). Probiotics are widely used in poultry farming as opposed to farm bred pheasants. Many authors studied the impact of probiotics on meat quality in broilers (Kabir, 2009; Hossain et al., 2012; Ivanović et al., 2012; Maiorano et al. 2012). There are a number of studies on yield, chemical composition and quality of meat of wild and farm bred pheasants (Richter et al., 1992; Tucak et al., 2008; Hofbauer et al., 2010). However, there are no studies on the quality of meat of pheasants, which orally ingest probiotics with feed and drinking water. Some studies analysed the effect of probiotics and organic form of minerals in pheasant's nutrition. In one study, commercial additive Sel-Plex® added in a concentration of 0.2% caused a significantly lower concentration of creatinine and triglycerides, a significantly higher level of band heterophils and a significantly lower skin and offal weight of pheasants. The highly valuable parts of the carcasses between groups were with no significant differences. Another additives group are prebiotics. Prebiotics are an additive contains as active compounds indigestive saccharides like fructooligosaccharides or mannanoligosaccharides. The mode of action is probiotics in intestine stimulation via source of energy and nutrients. However, probiotics are typical microorganisms in digestive tract of animals, and for their amount increasing; there are two ways, directive and non-directive (Gálik et al., 2016). On the market, there are many commercial products, like FOS® (fructooligosaccharides) or Bio-Mos® (bioactive substance of mannanoligosaccharides and active yeast *Saccharomyces cerevisiae*). Pheasants with application of Bio-Mos® (2 g*kg^{-1} of feed) had a higher level of glucose, triglycerides, lymphocytes and monocytes, but with no statistical significance, when compared to the control (Šperanda et al., 2008). Other feed additives, which can be use in pheasant fattening are phytoadditives or phytogenics (Gálik et al., 2014). The active base of these additives are different plant origin substances with strong stimulation effect of nutrients utilization and performance (Arpášová et al., 2010a; Arpášová et al., 2010b; Gálik et al., 2013).

Humic acids

Humic acids (HA) are organic compounds naturally present in water and soil. They form three-dimensional structure molecules, containing aromatic nuclei with oxygen and nitrogen heterocycles. In the side chains, bound to an aromatic nucleus, hydroxyl, carbonyl, carboxyl, amine and sulfhydryl functional groups are present (McCarthy 2001; Zralý et al., 2008). Due to different HA structures, the content of functional groups and various qualities (colloidal, spectral, electrochemical and ion exchange) their considerable adsorption capacity is assumed (Alvarez- Puebla et al., 2005). Colloidal characteristics of HA and their salts and their ability to form chelates, they can significantly modify the toxic effects of a number of xenobiotics and undesirable substances that enter the digestive tract together with feeds and water (Livens, 1991; Herzig et al., 1994). Their strong affinity to mutagens (Cozzi et al., 1993), pesticides (Negre et al., 2001; Li et al., 2003), monoaromatic and polycyclic aromatic compounds (Kollist Sügur et al., 1993; Nanny and Maza, 2001), heavy metals (Livens, 1991; Madroňová et al., 2001; Hammock et al. 2003; Herzig et al., 2007), aflatoxin B1 (Van Rensburg et al., 2006) and microorganisms (Fein et al., 1999) was described. Positive effects of oxihumolite resulting in a decreased ammonia concentration in the stable environment of market broilers were obtained by Suchý et al. (1999). Humic acid based mixtures have the potential to be an alternative to antibiotic growth promoters in broiler diets (Ceylan et al., 2003). Ceylan et al. (2003) and Bailey et al. (1996) reported that supplementation level of 0.25% humate (Biomoss, a different product of humic acids) enhanced body weight gain (BWG) of broilers. But Kocabaglı et al. (2002); Karaoglu et al. (2004) and Yalcin et al. (2005) have reported that 0.1-0.25% humate additions (HA) did not affect BWG of broilers. On the contrary, supplementation of 0.5-2.5% HA in ration decreased BWG of broilers (Rath et al., 2006). It was reported that HA supplementation in ration decreased feed consumption of broilers and hens (Rath et al., 2006). On the contrary, Ceylan et al., (2003) have reported that HA supplementation in ration did not affect feed consumption of broilers and hens. Differences in feed consumption may have resulted from the differences in amount of HA added to water. Also, Yasar et al., (2002) have reported that HA supplementation in drinking water of rats did not affect feed consumption. Humates promote growth by altering partitioning of nutrient metabolism (Stepchenko et al., 1991; Zhorina and Stepchenko, 1991; Parks, 1998; Kocabağli et al., 2002; El-Husseiny et al., 2008; Ozturk et al., 2012; Mirnawati and Marlida, 2013), and reducing mortality (Eren et al., 2000), and improving feed conversion efficiency (Shermer et al., 1998; Eren et al., 2000).

Conclusions

In conclusion, the improvement of knowledge of fattening pheasant process can help to identify optimum length of fattening on quality of meat and conformation of body weight of pheasants. To increase the efficiency of fattening of pheasants is possible to use different feed additives, with the specific position among themselves humic acids.

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References

Adamski, M., Kuzniacka, J. (2006) The effect of age and sex on slaughter traits of pheasants (*Phasianus colchicus* L.). Animal Science Papers and Reports, 24, 11-18.

Alvarez-Puebla, R.A., Goulet, P.J.G., Garrido, J.J. (2005) Characterization of the porous structure of different humic fractions. Colloids Surfaces A: Physicochemical and Engineering Aspects, 256, 129-135.

Arpášová, H., Haščík, P., Bujko, J. (2010a) Influence of plant essential oils on selected parameters of the performance of laying hens. Journal of Central European Agriculture, 11, 11-18.

Arpášová, H., Haščík, P., Hanová, M., Bujko, J. (2010b) Effect of dietary sodium selenite and Se-enriched yeast on egg-shell qualitative parameters of laying hens eggs. Journal of Central European Agriculture, 11, 99-104.

Bailey, C.A., White, K.E., Domke, S.L. (1996) Evalution of menefee humate tm on the performance of broilers. Poultry Science, 75, 84.

Baohua, W.U., Tao, L.I., Xiaoping, Y.U. (2010) Winter diet and digestive tract of the golden pheasant (*Chrysolophus pictus*) in the Qinling mountains, China. Chinese Birds 1, 45-50.

Ceylan, N., Ciftci, I., Ilhan, Z. (2003) The effects of some alternative feed additives for antibiotic growth promoters on the performance and gut microflora of broiler chicks. Turkish Journal of Veterinary and Animal Science, 27, 727-733.

Cozzi, R., Nicolai, M., Perticone, P., Desalvia, R., Spuntarelli, F. (1993) Desmutagenic activity of natural humic acids - Inhibition of mitomycin-C and maleic hydrazide mutagenicity. Mutation Research, 299, 37-44. Available at http://www.sciencedirect.com/science/article/pii/016512189390117V

Đorđević, M., Pekeč, S., Popović, Z., Đorđević, N. (2010) Influence of dietary protein levels on production results and mortality in pheasants reared under controlled conditions. Acta Veterinaria Beograd, 60, 79-88. DOI: 10.2298/AVB1001079D

El-Husseiny, O.M., Abdallah, A.G., Abdel-Latif, K.O. (2008) The influence of biological feed additives on broiler performance. International Journal of Poultry Science, 7, 862-871. DOI: 10.3923/ijps.2008.862.871

Eren, M., Deniz, G., Gezen, S.S., Turkmen, I.I. (2000) Broyler yemlerine katilan humatlarin besi performansı, serum mineral konsantrasyonu ve kemik külü üzerine etkileri. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 47, 255-263.

Feina, J.B., Boilyb, J.F., Gucluc, K., Kaulbacha, E. (1999) Experimental study of humic acid adsorption onto bacteria and Al-oxide mineral surfaces. Chemical Geology, 162, 33-45. Available at http://www.sciencedirect.com/science/article/pii/S0009254199000753?via%3Dihub

Gálik, B. (2012) The effect of phytogenic feed additives on nutrients utilization in non-ruminants. (Assoc. prof. thesis). Nitra: Slovak University of Agriculture.

Gálik, B., Arpášová, H., Bíro, D., Rolinec, M., Šimko, M., Juráček, M., Novotná, I. (2013) The effect of dietary *Rhus coriaria* L. supplementation on fatty acids composition in the table eggs. Acta Fytotechnica et Zootechnica, 16 (2), 49-52.

Gálik, B., Arpášová, H., Bíro, D., Rolinec, M., Šimko, M., Juráček, M., Herkeľ, R. (2014) The effect of dietary *Rhus coriaria* L. on table eggs yolk nutrients composition. Acta Fytotechnica et Zootechnica, 17 (3), 93-95. DOI: 10.15414/afz.2014.17.03.93_95

Gálik, B., Arpášová, H., Bíro, D., Rolinec, M., Šimko, M., Juráček, M. (2016) Fytobiotiká vo výžive hydiny. Slovenský chov, 33 (7), 33.

Gornowicz, E., Lewko, L., Pietrzak, M., Gornowicz, J. (2009) The effect of broiler chicken origin on carcase and muscle yield and quality. Journal of Central European Agriculture, 10, 193-200.

Hammock, D., Huang, C.C., Mort, G., Swinehart, J.H. (2003) The effect of humic acid on the uptake of mercury(II), cadmium(II), and zinc(II) by Chinook salmon (*Oncorhynchus tshawytscha*) eggs. Archives of Environmental Contamination and Toxicology, 44, 83-88. DOI: 10.1007/s00244-002-1261-9

Hell, P., Slamečka, J., Plavý, R. (2003) Morphometrics of free-ranging pheasants and pheasants from volaries related to race. Zeitschrift für Jagdwissenschaft, 49, 267-274.

Herzig, I., Hampl, J., Dočekalová, H., Písaříková, B., Vlček, J. (1994) The effect of sodium humate on cadmium deposition in the chicken organs. Veterinarni Medicina, 39, 175-185.

Herzig, I., Navrátilová, M., Suchý, P., Večerek, V., Totušek, J. (2007) Model trial investigating retention in selected tissues using broiler chicken fed cadmium and humic acid. Veterinarni Medicina, 52, 162-168.

Hofbauer, P., Smulders, F.J.M., Vodnansky, M., Paulsen, P., El-Ghareeb, W.R. (2010) A note on meat quality traits of pheasants (*Phasianus colchicus*). European Journal of Wildlife Research, 56, 809-813. DOI: 10.1007/s10344-010-0396-7

Hossain, M.E., Kim, G.M., Lee, S.K., Yang, C.J. (2012) Growth performance, meat yield, oxidative stability, and fatty acid composition of meat from broilers fed diets supplemented with a medicinal plant and probiotics. Asian-Australasian Journal of Animal Sciences, 25, 1159-1168. DOI: 10.5713/ajas.2012.12090

Ipek, A., Dikmen, B. Y. (2007) The relationship between growth traits and egg weight in pheasants (*P. colchicus*). Journal of Biodiversity and Environmental Sciences, 1, 117-120.

Ivanović, S., Pisinov, B., Maslic-Strizak, D., Savic, B., Stojanovic, Z. (2012) Influence of probiotics on quality of chicken meat. African Journal of Agricultural Research, 7, 2191-2196. DOI: 10.5897/AJAR11.1693

Jakešová, P., Zapletal, D., Jůzl, R., Rusníková, L., Suchý, P., Straková, E. (2014) Effect of age on contents of fatty acids in whole bodies of pheasants throughout their growth. Acta Veterinaria Brno, 83, 119-124. DOI: 10.2754/avb201483020119

Kabir, S.M.L. (2009) Effect of probiotics on broiler meat quality. African Journal of Biotechnology, 8, 3623-3627.

Karaoglu, M., Macit, M., Esenbuga, N., Durdag, H., Bilgin, O.C., Turgut, L. (2004) Effect of supplemental humate at different levels on the growth performance, slaughter and carcass traits of broilers. International Journal of Poultry Science, 3, 406-410. DOI: 10.3923/ijps.2004.406.410

Kocabagli, N., Alp, M., Acar, N., Kahraman, R. (2002) The effects of dietary humate supplementation on broiler growth and carcass yield. Poultry Science, 81, 227-230.

Kokoszyński, D., Bernacki, Z. (2008) Comparison of slaughter yield and carcass tissue composition in broiler chickens of various origin. Journal of Central European Agriculture, 9, 11-16.

Kokoszyński, D., Bernacki, Z., Korytkowska, H. (2008) The effect of adding whole wheat grain to feed mixture on slaughter yield and carcass composition in game pheasants. Journal of Central European Agriculture, 9, 659-664.

Kokoszyński, D., Bernacki, Z., Cisowska, A. (2010) The effect of using whole wheat grain in the diet of game pheasants on their body weight, dimensions and development of some internal organs. Folia biologica Kraków, 58, 101-106. DOI: 10.3409/fb58_1-2.101-106

Kokoszynski, D., Bernacki, Z., Cisowska, A. (2011) Growth and development of young game pheasants (*Phasianus colchicus*). Archiv für Tierzucht, 54, 83-92.

Kollist-Siigur, K., Nielsen, T., Gron, C., Hansen, P.E., Helweg, C., Jonassen, K.E., Jorgensen, O., Kirso, U. (2001) Sorption of polycyclic aromatic compounds to humic and fulvic acid HPLC column materials. Journal of Environmental Quality, 30, 526-537.

Krystianiak, S., Torgowski, J. (1998) The effect of two feeding systems on rearing results of pheasants (*Phasianus colchicus* L.) of Polish and French varieties. Applied Scientific Reports, 36, 201-209.

Kuźniacka, J., Adamski, M., Bernacki, Z. (2007) Effect of age and sex of pheasants (*Phasianus colchicus* L.) on selected physical properties and chemical composition of meat. Annals of Animal Science, 7, 45-53.

Kuźniacka, J., Adamski, M. (2010) Growth rate of body and measurements in pheasants reared up to the 24th week of life. Archiv für Tierzucht, 53, 360-367.

Lauková, A., Kandričáková, A. (2015) *Staphylococci* detected in faecal samples of Common Pheasants and their relation to enterocins. International Journal of Current Microbiology and Applied Sciences, 4, 788-797.

Lazar, V. (1990) Poultry rearing. University of Agriculture in Brno, 210.

Li, H., Sheng, G.Y., Teppen, B.J., Johnston, C.T., Boyd, S.A. (2003) Sorption and desorption of pesticides by clay minerals and humic acid-clay complexes. Soil Science Society of America Journal, 67, 122-131.

Livens, F.R. (1991) Chemical reactions of metals with humic material. Environmental Pollution, 70, 183-208. DOI: 10.1016/0269-7491(91)90009-L

Madronová, L., Kozler, J., Cezíková, J., Novák, J., Jánoš, P. (2001) Humic acids from coal of the North-Bohemia coal field. III. Metal-binding properties of humic acids - measurements in a column arrangement. Reactive and Functional Polymers, 47, 119-123. DOI: 10.1016/S1381-5148(00)00077-8

Maiorano, G., Sobolewska, A., Cianciullo, D., Walasik, K., Elminowska-Wenda, G., Slawinska, A., Tavaniello, S., Zylinska, J., Bardowski, J., Bednarczyk, M. (2012) Influence of in ovo prebiotic and synbiotic administration on meat quality of broiler chickens. Poultry Science, 91, 2963-2969. DOI: 10.3382/ps.2012-02208

Marzoni, M., Castillo, A., Romboli, I. (2005) Dietary inclusion of Quebracho (*Schinopsis lorentzii*) tannins on productive performances of growing pheasant females. Italian Journal of Animal Science, 4, 507-509. DOI: 10.4081/ijas.2005.2s.507

McCarthy, P. (2001) The principles of humic substances. Soil Science, 166, 738-751.

Mirnawati, Y.R., Marlida, Y. (2013) Effects of humic acid addition via drinking water on the performance of broilers fed diets containing fermented and non-fermented palm kernel cake. Archiva Zootechnica, 16, 41-53.

Mroz, E. (2003) Bażanty. Warsaw: Ed Hoża, 2003.

Nanny, M.A., Maza, J.P. (2001) Noncovalent interactions between monoaromatic compounds and dissolved humic acids: A. deuterium NMR T-1 relaxation study. Environmental Science & Technology, 35, 379-384. DOI: 10.1021/es0012927

Negre, M., Schulten, H.R., Gennari, M., Vindrola, D. (2001) Interaction of imidazolinone herbicides with soil humic acids. Journal of Environmental Science and Health, Part B, 36, 107-125. DOI: 10.1081/PFC-100103738

Novakova, S. (1991) The quality of poultry intended for slaughter and poultry meat. University of Agriculture in Brno, 81.

Ozturk, E. (2009) Effects of dietary humic substances on egg production and egg shell quality of hens after peak laying period. African Journal of Biotechnology, 8, 1155-1159.

Parks, C.W. (1998) The use of Menefee Humate TM in typical and low-crude protein diets for turkey toms and in the bioremediation of petroleum-contaminated soil amended with poultry litter as a co-substrate and nutrient source. (MSc. Thesis). Raleigh: North Carolina State University.

Rath, N.C., Huff, E.W., Huff, G.R. (2006) Effects of humic acid on broiler chickens. Poultry Science, 85, 410-414.

Ricard, F.H., Petitjean, M.J. (1989) A comparison of the compositions of game-type pheasants and broiler chickens with similar body weights. Annales De Zootechnie, 38, 11-18.

Ricard, F.H., Petitjean, M.J., Melin, J.M., Marche, G., Malineau, G. (1991) Growth rate and abdominal fat of young pheasants reared in aviaries or in confinement. Productions Animales, 4, 117-121.

Richter, G., Ochrimenko, C., Gruhn, K. (1992) Zusammensetzung und Qualitätsparameter von Perlhühnern, Fasanen, Tauben, Cairina und Kaninchen. Nahrung, 36, 543-550.

Sarica, M., Karacay, N. (1994) A research on the growth performance and carcass traits of pheasants. Turkish Journal of Veterinary and Animal Sciences, 18, 371-376.

Sarica, M., Karacay, N., Camci, O. (1999) Slaughter age and carcass traits of pheasants. Archiv für Geflugelkunde, 63, 182-184.

Shermer, C.L., Maciorowski, K.G., Bailey, C.A., Byers, F.M., Ricke, S. (1998) Caecal metabolites and microbial populations in chickens consuming diets containing amined humate compound. Journal of the Science of Food and Agriculture, 77, 479-486.

Shulin, X., Shen, X. (1998) Normal bacterial floras in intestinal tract of ring-necked pheasants. Journal of Forest Research, 9, 105-107. DOI: 10.1007/BF02864995

Stepchenko, L.M., Zhorina, L.V., Kravtsova, L.V. (1991) The effect of sodium humate on metabolism and resistance in highly productive poultry. Biologicheskie Nauki,10, 90-95.

Straková, E., Vitula, F., Suchý, P., Večerek, V. (2005) Growth intensity and carcass characteristics of fattened pheasant poults. Krmiva, 47, 73-82.

Straková, E., Suchý, P., Vitula, F., Večerek, V. (2006) Differences in the amino acid composition of muscles from pheasant and broiler chickens. Archiv für Tierzucht, 49, 508-514.

Straková, E., Suchý, P., Karásková, K.. Jámbor, M., Navrátil, P. (2011) Comparison of nutritional values of pheasant and broiler chicken meats. Acta Veterinaria Brno, 80, 373-377. DOI: 10.2754/avb201180040373

Suchý, P., Herzig, I., Písaříková, B. (1999) The use of sorbents on the basis of humic acids to reduce ammonia levels in stable environment. Veterinarni Medicina, 44, 331-338.

Šperanda, M., Florijančić, T., Bošković, I., Bogut, I., Gutzmirtl, H., Grgurić, D., Senčić, Đ., Antunović, Z. (2008) The effects of organic selenium and mannan oligosaccharides on the productivity and health of pheasant chicken (*Phasianus colchicus*). In Acta Veterinaria-Beograd, 58, 63-73. DOI: 10.2298/AVB0801063S

Tapeli, C., Krkc, K., Cetin, O., Ylmaz, A. (1999) Growth, fattening performance, slaughter and carcass characteristics of pheasant (*P. colchicus*) in different age. Veterner Bilimleri Dergisi, 15, 29-34.

Torgowski, J., Potkański, A., Musiał, K. (1990) Effect of different feeding and housing systems on rearing results of pheasant. Annals of University Agricultural Poznań, 214, 99-109.

Tucak, Z., Škrivanko, M., Posavčević, Š., Periškić, M., Bošković, I., Jumić, V. (2008) The influence of keeping pheasants in captivity *vs*. nature on the biological value of meat and its use in human nutrition. Collegium Antropologicum, 32, 959–962.

Van Rensburg, C.J., Van Rensburg, C.E.J., Van Ryssen, J.B.J., Casey, N.H., Rottinghaus, G.E. (2006). *In vitro* and *in vivo* assessment of humic acid as an aflatoxin binder in broiler chickens. Poultry Science, 85, 1576-1583.

Večerek, V., Suchý, P., Strakova, E., Vitula F., Mikundová, M. (2005) Variation in the chemical composition of muscles in young pheasants during their growth. Archiv für Tierzucht, 48, 290-298.

Vitula, F., Suchý, P., Straková, E., Karásková, K., Zapletal, D., Kroupa, L. (2011) Energy value of meat in selected species of feathered game. Acta Veterinaria Brno, 80, 197-202. DOI: 10.2754/avb201180020197

Zapletal, D., Suchý, P., Straková, E. (2012) Technologie výkrmu bažantích kuřat pro produkci masa. Brno: VFU Brno. ISBN: 978-80-7305-615-5

Zelenka, J., Elnsabbach, M. T., Lazar, V. (1989) Growth, feed conversion and analysis of chicken carcass on intensive fattening. Zivocisna Vyroba, 34, 989-996.

Zhorina, L.V., Stepchenko, L.M. (1991) The content of free amino acids in the tissues of broiler chicks administered sodium humate in the ration. Biologicheskie Nauki, 10, 147-150.

Zralý, Z., Písaříková, B., Trčková, M., Navrátilová, M. (2008) Effect of humic acids on lead accumulation in chicken organs and muscles. Acta Veterinaria Brno, 77, 439-445. DOI: 10.2754/avb200877030439

Yalcin, S., Ergun, A., Erol, H., Yalcin, S., Ozsoy, B. (2005) Use of L-carnitine and humate in laying quail diets. Acta Veterinaria Hungarica, 53, 361-370. DOI: 10.1556/AVet.53.2005.3.9

Yasar, S., Gokcimen, A., Altuntas, I., Yonden, Z., Petekkaya, E. (2002) Performance and ileal histomorphology of rats treated with humic acid preparations. Journal of Animal Physiology and Animal Nutrition, 86, 257-264. DOI: 10.1046/j.1439-0396.2002.00383.x