J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Penguatan Risbang No. 60/E/KPT/2016

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
43(2):107-114, June 2018
DOI: 10.14710/jitaa.43.2.107-114

Effect of binder mineral in batchery waste based feed pellet on its proximate component and energy values

B. Sulistiyanto*, C. S. Utama and S. Sumarsih
Faculty of Animal and Agricultural Sciences, Diponegoro University,
Tembalang Campus, Semarang 50275 - Indonesia
**Corresponding E-mail: bsoel07@gmail.com*

Received September 09, 2017; Accepted January 10, 2018

ABSTRAK

Penelitian dilakukan dengan maksud untuk mengkaji pengaruh penambahan mineral pengikat pada proses pengolahan terhadap komponen proksimat dan nilai energi pellet berbahan dasar limbah penetasan. Hasil penelitian diharapkan memberikan manfaat dalam menyediakan sumber bahan pakan baru untuk usaha peternakan lokal. Limbah penetasan yang terdiri atas 30% cangkang telur, 60% telur gagal menetas dan 10% DOC afkir dihaluskan dan dicampur dengan 10% onggok (B/B), selanjutnya dicampur rata dengan mineral pengikat (bentonit atau zeolit) dengan aras 0, 1, 2, 3, 4 dan 5% (B/B). Hasil campuran dilakukan pengkondisian dengan cara pengukusan pada suhu 80 ºC selama 15 menit, dan dicetak menjadi pellet dengan ukuran panjang 30 mm dan diameter 6 mm, selanjutnya pellet dikeringkan pada alat pengering aliran udara panas. Parameter yang diukur meliputi kadar air, protein kasar (PK), ekstrak ether (EE), serat kasar (SK), Energi metabolis semu dan nyata (AME dan TME), nilai metabolisabilitas, serta nilai retensi nitrogen pellet. Hasil penelitian menunjukkan bahwa kadar air pellet menurun dengan penambahan zeolit maupun bentonit ($P<0.05$). Meskipun pengaruh perlakuan penambahan mineral pengikat berbeda dalam polanya, kadar abu, PK, EE dan SK menunjukkan peningkatan dengan meningkatnya aras mineral pengikat ($P<0.05$). Kemanfaatan nutrisi yang diukur dari energi metabolis (AME, TME), metabolisabilitas dan retensi nitrogen meningkat sejalan dengan penambahan bentonit, maupun zeolit ($P<0.05$). Disimpulkan bahwa penambahan bentonit dan zeolit pada pembuatan pellet limbah penetasan dapat memperbaiki kandungan komponen proksimat dan nilai kemanfaatan nutrisinya.

Kata kunci: bentonit, zeolit, proksimat, energi, pellet, limbah penetasan

ABSTRACT

The Experiment was conducted to study effects of binder mineral addition to the hatchery waste based pellet processing on its proximate component and energy value. The study may be beneficial to emerge a new feed resource for local farm businesses. The hatchery wastes those comprised of 30% of egg shells, 60% of un-hatched eggs, and 10% of culled DOC were blended, and mixed with 10% of cassava cake meal(W/W), then mixed well with mineral adsorbent (bentonites or zeolites) at 0, 1, 2, 3, 4 and 5% (W/W). The mixture was conditioned at 80 ºC for 15 min, and extruded to make a pellet with 6 mm of diameter and 30 mm in length, and dried into warm air flow dryer. The moisture, crude protein (CP), ash, ether extract (EE), crude fiber (CF), apparent metabolizable energy (AME), true metabolizable energy (TME), metabolizability(MET) and nitrogen retention (NR) were observed in each pellet. Result of the experiment showed that moisture of pellet was decreased ($P<0.05$) by zeolites or bentonites addition. Even though the effect of binder mineral addition gave different patterns, concentrations of ash, crude protein, ether extract and crude fiber of pellet product were increased by increasing level of mineral adsorbent (P<0.05). Nutrient availability as was represented by AME, TME, MET, and NR were increased by zeolites and bentonites additions (P<0.05). In conclusion, supplementations of bentonites and zeolites in the hatchery waste based pellet could improve its proximate component concentration and nutrient availability.

Keywords: bentonite, zeolite, proximate, energy, pellet, hatchery wastes

INTRODUCTION

Hatchery waste has a good nutrient content (Mehdipour *et al*., 2009). The protein from the hatchery waste have high biological value, a good balance of amino acids, as well as competitiveness compared to the prices of soy and fish meal (Lilburn *et al*., 1997; Shariar *et al*., 2008). The hatchery wastes have 60% water, 20% crude protein and 9% crude lipid. This nutrient composition fact contributes the microorganism growth, so that the hatchery waste may be easily damaged, rotten and smelling when it is not handled well.

Pelletizing has been proven to increase the effectiveness of growth inhibition of fungi in the feed. A Heating with high-pressure treatment in the pelleting process does not effect on amino acid and energy availability and the feed conversion may be unaffected (Serrano *et al*., 2013 and Cutlip *et al*., 2008). Some studies used mineral binder in the feed for various purposes, such as the use of kaolin, bentonite and zeolite as feed supplements, calcium lignosulfonate and sepiolite in pelleting broiler feed, sodium bentonite for binding aflatoxin, as well as the zeolite to improve the utility of nutrients (Trckova *et al.,* 2004; Corey *et al*., 2014; Pasha *et al*., 2007; Leung *et al*., 2007). Zeolites is known to be safe for poultry feed to enhance nutrient utilization and animal growth. Zeolites have beneficial effects on feed efficiency ratio, water consumption, nutrient utilization, manure and litter condition (Shariatmadari, 2008 and Karamanlis *et al*., 2008). Zeolites been reported to be effective in absorbing nitrates and ammonia (Mažeikiene *et al*., 2008), decreasing the number of E-coli reducing the effect of aflatoxin on broiler chickens (Miazo *et al*., 2000; Affsal and Zahid, 2004), increasing the utility of Zn, suppressing the Salmonella and improving the broiler growth (Al-Nasser *et al*., 2011, Mallek *et al*., 2012).

However, there is a lack of information concerning with zeolites and bentonites effects on hatchery waste based pellet feed processing. Therefore, this study examined the ability of zeolites and bentonites in improving the quality of hatchery waste based pellet.

MATERIALS AND METHODS

Materials

Hatchery wastes consisted of egg shells, rotten eggs, unhatched eggs, and culled DOC were obtained from PT. Intertama Tri Kencana Hatcheries, Semarang. Cassava Cake meal (CCM), non-bleaching bentonite and zeolite were purchased from local suppliers.

Methods

Two series of experiments were conducted to determine the effect of binders mineral, that were zeolite and bentonite. The experiment was conducted using a completely randomized design with 6 treatments and 3 replications of each.

A total of 30% of egg shells, 60% of unhatched eggs, and 10 % of culled DOC mixed and blended for 5 minutes, then added with CCM as a filler at 10% (W/W in fresh weight) and thoroughly mixed well. After that, binder minerals (zeolite or bentonite) according to the treatment was administered into the mixture at 0, 1, 2, 3, 4 and 5% (W/W), then mixed well. The mixtures were conditioned at a temperature of ± 80℃ for 15 minutes and pelletized by an extruder to make pellets with a diameter of 6 mm and length of 30 mm. The wet pellets were dried on warm air flows until the moisture content reached at 10-12%.

Assay

The content of proximate components such as moisture, ash, crude protein, ether extract and crude fiber of pellets were analyzed according to the method of AOAC (AOAC, 1975).

The apparent metabolizable energy (AME), true metabolizable energy (TME), metabolizability (MET) and N-retentions (NR) determination of the hatchery waste pellet was conducted as reported previously (Sulistiyanto *et al*., 1999) and Sulistiyanto, 2001). In the ME determination of pellet, sixty-three native DOC were reared in 21 metabolic cages (18 cages of fed birds and 3 cages of unfed birds) with dimention of L x W x H = 40 x 50 x 40 cm of each. There were three birds in each cage. Experiment was conducted with 3 replications of each pellet according to level of binder mineral 0, 1, 2, 3, 4, 5% and unfed birds.

The chickens were fed *at libitum* using a commercial ration for 9 days (1.1 % of Ca, 0.8% of P, 6% of Ash, 5 % of CF, 7% of EE, 22% of CP and 3100 kcal/kg of ME). At days 9th, chickens were feed deprived with free access to drinking for 24 hours. At days 10th, chickens were force fed with pellets 3 times during 8 hours to reach the amount of feed 10-12% of body weight, and then chickens were starved with free access to drinking for 36 hours from the last forced feeding. Excreta were collected for 44 hours started from the first forced feeding. Excreta were then frozen, dried, and weighed. The contents of gross energy (GE) and crude protein of pellet and excreta were determined using bomb calorimeter and micro Kjeldahl (AOAC, 1975), respectively.

Data were statistically analyzed using general linear model of SAS (GLM-SAS, 1995)

RESULTS AND DISCUSSION

Proximate Component

Table 1 shows that inclusion of zeolites and bentonites in the pelletizing process of hatchery wastes significantly affected nutrients content ($P < 0.05$). Moisture of pellets significantly decreased with increasing level of zeolites ($P<0.05$). Percentage of ash increased with zeolites levels, but the effect was significant when the levels reach to 3% ($P<0.05$). Ether extract (EE) content significantly increased by treatments of zeolites ($P<0.05$). Ether extract of control pellets (0% of zeolites) was lower than EE of treated pellets ($P<0.05$). However, there was no significant effect the zeolites levels 1, 2, 3, 4 and 5% to the EE of pellets. Crude protein (CP) content of pellet increased with level of zeolites. The effect to CP became significant when the zeolites levels reached 2% and more ($P<0.05$). Effect of zeolites on crude fiber (CF) content of pellet in different ways. Among the treatments, the CF of pellets contained 3 and 4 % were significantly higher than that the level of zeolites 0, 1, 2 and 5 %.

Effect of bentonites on the pellet moisture was significant ($P<0.05$). Moisture of control pellets (0% of bentonites) was significantly lower than that of treated pellets, but among the level of bentonites, there was no significantly different. The effect of bentonites to the ash emerged significant ($P<0.05$) when the level of bentonite became 2%. Percentage of EE of the pellets was significantly increased by bentonites ($P<0.01$). In comparing to bentonites treated pellets, ether extract of control pellets was the lowest. Effect of bentonites on the CP emerged in different patterns. The CP of pellets significantly increased gradually up to 2% of bentonites and gradually decreased thereafter. Among the treatments, CP of control pellets was lower than that of treated pellets. In the similar way of the CP, the CF of pellet significantly increased gradually up to 3% of bentonites and decreased thereafter ($P<0.05$). Among the treatments, CP of control pellets was lower than that of bentonites treated pellets.

The results showed that the zeolite or bentonite have positive effects on moisture reduction in hatchery waste pellets. Nassari *et al.* (2014) reported that alumino silicate (zeolite) will continue to absorb water until all of their pores are filled, the ratio of zeolite-bead varies according to the beads moisture absorbing capacity and the moisture percentage of materials dried. Increasing levels of zeolite accelerate water evaporation and increasing the number of zeolites that were used would decrease the moisture content of the final products of drying to be lesser, while the levels of protein and fat are relatively constant. Ability to reduce the water content by a mineral adsorbents such as kaolin, bentonite, and zeolite was also reported by Katouli *et al.* (2010). The ability of adsorption of water and organic matter is the most common attribute of healing clays such as bentonite and zeolites. The water and organic matter had been embedded into interlayer, then an interlayer water and hydroxyl groups from clays were removed by heating (William and Haydel, 2010). In spite of increasing of pellet aggregates, bentonite also able to reduce the water content of the pellets (Manikandan and Ramamurthy, 2009). The addition of zeolite and bentonite lead to increased levels of the ash. That was in harmony with Ergun *et al.* (2008) who reported that an administration of zeolite on the rations would increase the ash content since the ash is the main component of zeolites. The composition of proximate components is basically the ratio of the number of components measured in the material so that changes in one component would affect the others. The addition of bentonite as well as zeolite were able to bound water and then released them during the drying process, so it caused low moisture content of pellets. The binding ability of zeolite and bentonite to organic material as was noted by William and Haydel

Tabel 1. Effect of Addition of Zeolites and Bentontites in the Pelletizing on Proximate Component of Pellets

Treatments	Moisture	Ash	Extract Ether (EE)	Crude Protein (CP)	Crude fibre (CF)
Level of Zeolites					
		-------%------			
0%	8.68 ± 0.75[a]	49.36 ± 3.93[b]	8.38 ± 0.47[b]	21.44 ± 1.31[c]	6.88 ± 0.52[b]
1%	5.67 ± 0.47[b]	50.82 ± 2.49[b]	8.78 ±0.54[ab]	23.35 ± 0.68[bc]	6.82 ± 0.79[b]
2%	5.58 ± 0.37[b]	51.06 ± 2.62[b]	8.88 ± 0.69[a]	23.50 ± 0.89[b]	6.97 ± 1.06[b]
3%	5.54 ± 0.46[b]	52.38 ± 1.15[a]	9.11 ± 0.89[a]	24.74 ± 0.34[b]	7.37 ±0 .58[a]
4%	5.47 ± 0.33[b]	53.04 ± 1.33[a]	9.00 ± 0.76[a]	25.09 ± 0.83[a]	7.36 ± 0.44[a]
5%	4.59 ± 0.64[b]	53.72 ± 1.06[a]	8.97 ± 0.48[a]	25.68 ± 1.17[a]	6.94 ±0 .63[b]
Level of Bentonites					
0%	7.66 ± 0.74[a]	48.60 ± 2.51[b]	7.45 ± 0.29[c]	21.06 ± 0.76[d]	6.76 ± 0.25[d]
1%	5.18 ± 0.54[b]	50.02 ± 0.72[b]	7.91 ± 0.55[b]	27.74 ± 2.86[b]	7.47 ± 0.60[c]
2%	4.98 ± 0.54[b]	52.07 ± 1.70[a]	8.59 ± 0.37[a]	28.86 ± 0.93[a]	7.68 ± 0.39[b]
3%	5.10 ± 0.47[b]	52.30 ± 1.09[a]	8.41 ± 0.33[a]	28.02 ± 0.33[a]	7.75 ± 0.84[a]
4%	4.99 ± 0.51[b]	53.39 ± 2.22[a]	8.55 ± 0.25[a]	27.90 ± 0.93[b]	7.67 ± 0.49[b]
5%	4.98 ± 0.50[b]	54.17 ± 1.30[a]	8.46 ± 0.36[a]	27.56 ± 2.01[c]	7.52 ± 0.37[c]

Values are means of three replicates (n=3 ± SD)
[a,b,c] Means within same column with different superscripts were significantly different (P<0.05)

(2010), zeolite and bentonite had been reported effective on ammonia absorption, reducing odor and moisture of poultry dropping, thus may lead improvement the percentage of EE, CP and CF to be better than the control. Effect of zeolite as well as bentonite in this experiment in harmony with the effect to the physic-organoleptic pellets, inclusion of binders up to 3-4% effectively reduced odor and improved the texture of pellet hatchery wastes.

Energy Values

Effect of inclusion of zeolite and bentonite in the pelletizing process of hatchery wastes on gross energy (GE), apparent metabolizable energy (AME), true metabolizable energy (TME), metabolizability (MET) and N-retentions (NR) of pellets are presented in Table 2. There was no significant effect of zeolites and bentonites on GE of pellet product. However, inclusion of zeolite and bentonite in the pelletizing process significantly effected on the AME, TME, MET and NR of pellet (P<0.05). AME of pellet made with zeolite increased gradually up to the level of zeolites 3% and then decreased thereafter. The AME of pellet containing zeolites (1, 2, 3, 4 and 5%) were significantly higher than that the control (0%). The TME was highest at 3% level of zeolite. Level of zeolites at 1% was not yet provided significant effect on the TME (TME of pellet with 0 and 1 % were relatively same), the effect was significant when the level became 2% and more. Effect of zeolites on the MET was in different pattern. even though the MET was significantly higher at level zeolites 3%, there was no significant effect between the zeolites levels of 0, 4 and 5% as well as level 1 and 2%. Nitrogen retention of pellet significantly were increased

Table 2. Gross Energy, Apparent Metabolizable Energy, True Metabolizable Energy, Metabolizability and N-retention of Pellets

Treatments	GE	AME	TME	Metabolizability	N- retention
	-----------kcal/kg---------			--%--	---%--
Zeolite (%)					
0	2033 ± 59^{a}	990 ± 51^{b}	1820 ± 118^{b}	89.49 ± 6.15^{b}	71.64 ± 1.32^{b}
1	1989 ± 30^{a}	1113 ± 57^{a}	1905 ± 62^{b}	94.19 ± 1.53^{ab}	84.83 ± 4.21^{a}
2	2223 ± 76^{a}	1313 ± 82^{a}	2102 ± 6 ^{a}	94.57 ± 3.15^{ab}	87.83 ± 5.51^{a}
3	2198 ± 117^{a}	1432 ± 121^{a}	2125 ± 125^{a}	96.67 ± 1.42^{a}	84.90 ± 6.39^{a}
4	2139 ± 113^{a}	1393 ± 120^{a}	1938 ± 87^{a}	90.59 ± 1.52^{b}	83.21 ± 3.18^{a}
5	2244 ± 45^{a}	1308 ± 60^{a}	2061 ± 50^{a}	91.84 ± 0.74^{b}	83.68 ± 5.79^{a}
Bentonite (%)					
0	2147 ± 45^{a}	1114 ± 160^{b}	1854 ± 186^{b}	84.40 ± 6.82^{b}	74.73 ± 3.41^{b}
1	2145 ± 114^{a}	1148 ± 146^{b}	2006 ± 77 ^{b}	93.25 ± 1.78 ^{ab}	84.34 ± 4.48^{a}
2	2058 ± 57^{a}	1116 ± 73^{b}	1896 ± 46^{b}	92.13 ± 1.73^{b}	85.03 ± 4.34^{a}
3	2321 ± 65^{a}	1424 ± 104^{a}	2226 ± 87^{a}	96.02 ± 1.24^{a}	86.30 ± 5.16^{a}
4	2202 ± 40^{a}	1363 ± 115^{a}	2060 ± 125^{a}	93.53 ± 5.36^{ab}	85.65 ± 2.14^{a}
5	2256 ± 62^{a}	1311 ± 58^{a}	2123 ± 17 ^{a}	94.14 ± 2.49^{ab}	86.04 ± 4.68^{a}

Values are means of three replicates (n=3 ± SD)

^{a,b,c} Means within same column with different superscripts were significantly different(P<0.05)

with levels of zeolites inclusion. Among the treatments, the NR of pellet without zeolites (0%) was the lowest in comparison to the pellet with zeolites additions.

The GE of pellets with bentonites were relatively same. Even though AME of pellet was increased up to the level of bentonites 3% and then relatively constant thereafter, there was no significant difference among the AME of pellets containing bentonites at 0, 1 and 2%. The AME of the pellets with bentonites at 3, 4 and 5% were significantly higher than the AME of bentonites levels at 0, 1, and 2 %. The TME value was high at 3% levels of bentonites. Level of bentonites up to 2% did not effect on the TME(p>0.05), the effect was significant when the level became 3-5% (p<0.05). Effect of bentonite on the energy utilization as was expressed on the metabolizability values were different in patterns, even though the energy utilization was significantly higher at level zeolites at 3% than that at 0, 4 and 5%, there was no significant difference among the bentonites levels of 1, 4 and 5%. Nitrogen retention of pellets was increased with levels of bentonites. Among the treatments, the NR of the pellet with bentonites at 0% was the lower than the pellet with zeolites at 1, 2, 3, 4 and 5%.

Addition of binder mineral has reduced an unpleasant odor of hatchery waste pellet. Moreover, AME, TME, MET or NR increased by the inclusion of zeolites and bentonites. This indicated that the structure the mineral binders were able to bind organic compounds temporarily, and then releasing them in the gastrointestinal tract, so it can be utilized effectively by the animals. Papaioannou *et al*. (2002, 2005) reported that the hydrated aluminosilicates consisting of three-dimensional networks of SiO44– and AlO45– tetrahedral have the ability to exchange constituent cations without a major change of structure, and releases or gaines water molecules reversibly. Effect of zeolites and bentonites on improving the utilization of nutrients in this study were consistent with the Pasha *et al*. (2008), Katouli *et al*. (2010), Nikolakakis *et al.* (2013) and Ani *et al*. (2015). They noted that utilization of binders as feed additive in the broiler rations up to 5% had positive effect to the animal performances and its meat quality. The inclusion of mineral binders such as bentonite could improve the digestibility of amino acids (Wamsley and Moritz, 2012). Clinoptilolites were shown to be highly effective with regard to the metabolic utilization of nitrogen in poultry and pigs. This may indicate that binders may decrease the concentration of nitrogenous containing substances in a feeding without affecting the performance of animals (Strakova *et al*., 2008). Ammonia is very harmful to animals and may be adsorbed by clinoptilolite (Shurson *et al.,* 1984), this could be considered to the reason for increasing the NR as well as AME and TME of zeolites based hatchery wastes pellets in this experiment. Subramaniam and Kim (2015) reported that the improvement of nutrient digestibility could be explained that clays reduce the speed of passage of feed along the digestive tract, therefore allows more time for digestion, thus increasing nutrient digestibility. Meanwhile, Zhou *et al*. (2014) clarifies that the improvement is achieved by increasing the secretion of digestive enzymes, enhancing the digestibility of nutrients, promoting the intestinal health of broiler chickens. Increased utilization of nutrients is also due to the increased viscosity of the digesta as a result of a decrease in water levels in the small intestine digesta (Bouderoua *et al.,* 2016). Energy has always played a central economic function in the production of farm animals. Establishing correctly interrelations between dietary metabolizable energy and the amount of feed consumption are the critical aspects for improving the precision of feed formulations. Therefore, the nutrient bio-availability of hatchery wastes pellet improved by administration inclusion of minerals binders was a valuable contribution to promote unconventional feedstuff for local farmers.

CONCLUSION

Hatchery waste based pellet with addition of mineral binders could be promoted as unconventional feedstuff. Inclusions of bentonite and zeolite 3% was recommended to be the best levels for increasing quality pellets. Further experiment was needed to study the effect of supplementation pellet hatchery on physiological and production performances of chickens.

ACKNOWLEDGEMENT

Authors greatly acknowledge to Diponegoro University, Semarang, Indonesia for the financial support to this research by the contract No. SP DIPA-042.01.2.400898/2016, dated December 7th, 2015.

REFERENCES

Afzal, M. and S. Zahid. 2004. Effects of addition of a mycotoxin detoxifier in poultry feed containing different levels of aflatoxins on the performance of broilers. Asian-Aust. J. Anim. Sci. 17(7): 990-994.

Al-Nasser, A. Y., S.F. Al-Zenki, S.E. Al-Saffar, F.K. Abdullah, M.E. Al-Bahouh and M. Mashaly. 2011. Zeolite as a feed additive to reduce Salmonella and improve production performance in broilers. Int. J. Poult Sci, 10: 448-454.

Ani, A.O., C.C. Ogbu and E.A. Iloh. 2014. Response of broiler chicks to diets containing graded levels of clay. J. Anim. Plant Sci. 24(1): 30-34.

AOAC. 1975. Official Methods of Analysis. 12th Ed. Association of Official Analytical Chemists, Washington DC.

Bouderoua, Y., D.Ait-Saada, G.Selselet-Attou, J. Mourot, C. Perier and G. Robin. 2016. Effects of dietary addition of raw and treated calcium bentonite on growth, digesta characteristics, blood profiles and meat fatty acids composition of broilers chicks. Asian J. Anim. Vet. Adv. 11(12): 805-814.

Corey, A. M., K. G. S. Wamsley, T. S. Winowiski and J. S. Moritz. 2014. Effects of calcium lignosulfonate, mixer-added fat, and feed form on feed manufacture and broiler performance. J. Appl. Poult. Res. 23:418-428.

Cutlip, S.E., J. M. Hott, N.P. Buchanan, A.L. Rack, J.D. Latshaw and J.S. Moritz. 2008. The effect of steam-conditioning practices on pellet quality and growing broiler nutritional value. J. Appl. Poult. Res. 17(2):

249-261.
Ergün, S., H. Tekesoglu and M. Yigit. 2008. Effects of dietary natural zeolite levels on ammonia excretion rates in young rainbow trout (*Oncorhynchus mykiss*). Fresen Environ. Bull. 7(2):245-248
Karamanlis X., P. Fortomaris, G. Arsenos , I. Dosis, D. Papaioannou, C. Batzios and A. Kamarianos . 2008. The effect of a natural zeolite (clinoptilolite) on the performance of broiler chickens and the quality of their litter. Asian-Aust. J. Anim. Sci. 21(11): 1642-1650
Katouli, M. S., F. Boldaji, B. Dastar and S. Hassani, 2010. Effect of different levels of kaolin, bentonite and zeolite on broilers performance. J. Bio. Sci. 10: 58-62.
Leung, S., S. Barrington, Y. Wan, X. Zhao and B. El-Husseini. 2007. Zeolite (*clinoptilolite*) as feed additive to reduce manure mineral content. Bioresource Tech. 98: 3309–3316.
Lilburn, M.S., G. W. Barbour, R. Nemasetoni, C. Coy, M. Werling and A. G. Yersin. 1997. Protein quality and calcium availability from extruded and autoclaved turkey hatchery residue. Poult. Sci. 76: 841–848
Mallek, Z., I. Fendri, L. Khannous, A.B. Hassena, A.I. Traore, M.A. Ayadi, R. Gdoura. 2012. Effect of zeolite (clinoptilolite) as feed additive in Tunisian broiler on the total flora, meat texture and the production of omega 3 polyunsaturated fatty acid. Lipid in Health and Disease.11: 35
Manikandan, R and K. Ramamurthy. 2009. Swelling characteristic of bentonite on pelletization and properties of fly ash aggregates. J. Mater. Civ. Eng. 21(10): 578-586.
Mažeikiene, A., M. Valentukevičiene, M. Rimeika, A.B. Matuzevičius and R. Dauknys. 2008. Removal of nitrates and ammonium ions from water using natural sorbent zeolite (clinoptilolite). J. Environ. Eng. Land Man. 16(1):38-44.
Mehdipour, M., M. Shams Shargh; B. Dastar and S. Hassani, 2009. Effects of different levels of hatchery wastes on the performance, carcass and tibia ash and some blood parameters in broiler chicks. Pakistan J. Bio. Sci. 12: 1272-1276.
Miazzo, R., C.A.R. Rosa, E.C. De Queiroz Carvalho, C. Magnoli, S.M. Chiacchiera, G. Palacio, M. Saenz, A. Kikot, E. Basaldella and A. Dalcero. 2000. Efficacy of synthetic zeolite to reduce the toxicity of aflatoxin in broiler chicks. Poult. Sci. 79: 1–6
Nassari, P. J., K. Keshavulu, M. Rao, K.C.S. Reddy and A. Raheem. 2014. Post harvest drying of tomato (Lycopersicon esculentum Mill) seeds to ultra low moisture safe for storage using desiccant (zeolite) beads and their effects on seed quality. Am. J. Res. Com. 2(4): 74-83
Nikolakakis, I., V. Dotas, A. Kargopoulos, L. Hatzizisis, D. Dotas and Z. Ampas. 2013. Effect of natural zeolite (*clinoptilolite*) on the performance and litter quality of broiler chickens. Turk. J. Vet. Anim. Sci. 37:682-686.
Papaioannou, D. S., S. C. Kyriakis, A. Papasteriadis, N. Roumbies, A. Yannakopoulos and C. Alexopoulos. 2002. A field study on the effect of in-feed inclusion of a natural zeolite (clinoptilolite) on health status and performance of sows/gilts and their litters. Res. Vet. Sci. 72: 51-59.
Papaioannou, D., P. D. Katsoulos, N. Panousis and H. Karatzias. 2005. The role of natural and synthetic zeolites as feed additives on the prevention and/or the treatment of certain farm animal diseases: A review. Microporous Mesoporous Mat. 84: 161-170.
Pasha, T.N, M.U. Farooq, F.M. Khattak, M.A. Jabbar and A.D. Khan. 2007. Effectiveness of sodium bentonite and two commercial products as aflatoxin absorbents in diets for broiler chickens. Anim. Feed Sci.Tech. 132: 103-110.
Pasha, T.N., A. Mahmood, F.M. Khattak, M.A. Jabbar and A.D. Khan. 2008. The effect of feed supplemented with different sodium bentonite treatments on broiler performance. Turk. J. Vet. Anim. Sci. 32: 245-248
SAS., 1995. SAS User's Guide: Statistics. SAS Institute Inc., Cary.NC.
Serrano, M.P., M. Frikha, J. Corchero and G.G. Mateos. 2013. Influence of feed form and source of soybean meal on growth performance, nutrient retention, and digestive organ size of broilers. 2. Battery study. Poult. Sci. 92(3): 693-708.
Shariatmadari, F. 2008. The application of zeolit in poultry production. World's Poult. Sci. J. 64:76-84.
Shahriar, H.A., K. Nazer-Adl, J. Doolgarisharaf

and H. Monirifar. 2008. Effects of dietary different levels of hatchery wastes in broiler. J. Anim. Vet. 7(1):100-105.

Shurson, G.C., Ku P.K., Miller, E.R. and Yokoyama, M.T. 1984. Effects of zeolite a clinoptilolite in diets of growing swine. J. Anim. Sci. 59:1536-1545.

Strakova, E., R. Pospisil, P. Suchy, L. Steinhauser and I. Herzig. 2008. Administration of Clinoptilolite to Broiler Chickens During Growth and Its Effect on the Growth Rate and Bone Metabolism Indicators. Acta Vet. Brno. 77: 199-207**.**

Subramaniam, M.D. and Kim I.H. Clays as dietary supplements for swine: A review. J. Anim. Sci. Biotech. 6(1):38.

Sulistiyanto, B., Akiba, Y., & Sato, K. 1999. Energy utilisation of carbohydrate, fat and protein sources in newly hatched broiler chicks. Br. Poult. Sci. 40(5):653-659.

Sulistiyanto, B. 2001. Studies on Physiological and Metabolic Responses to Carbohydrate Loading in Newly Hatched Broiler Chicks. Ph.D Thesis. Tohoku University. Sendai, Japan.

Trckova, M., L. Matlova., L. Dvorska and I. Pavlik. 2004. Kaolin, bentonite, and zeolites as feed supplements for animals: health advantages and risks. Vet. Med. Czech. 49(10):389-399.

Wamsley, K. G. S and J. S. Moritz. 2012. Resolving poor pellet quality and maintaining amino acid digestibility in commercial turkey diet feed manufacture. J. Appl. Poult. Res. 22: 39-446.

Williams1, L.B. and S.E. Haydel. 2010. Evaluation of the medicinal use of clay minerals as antibacterial agents. Int. Geol. Rev. 52(7):745-770.

Zhou, P., Y.Q. Tan, L. Zhang, Y.M. Zhou, F. Gao and G.H. Zhou. 2014. Effects of dietary supplementation with the combination of zeolite and attapulgite on growth performance, nutrient digestibility, secretion of digestive enzymes and intestinal health in broiler chickens. Asian-Aust. J. Anim. Sci. 27(9):1311-1318.