Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6[4] March 2017: 04-08

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

REVIEW ARTICLE **OPEN ACCESS**

Application of Nano Minerals in the Field of Animal Nutrition: A Review

Sandeep Uniyal[1], N. Dutta[1], M. Raza[2], S.K. Jaiswal[2], J.K. Sahoo[1], Ashwin K[1]
[1]Division of Animal Nutrition, [2]Division of Poultry Science, Indian Veterinary Research Institute, Izatnagar, Bareilly, U.P.-243122

ABSTRACT
As we know from the previous studies that the bioavailability minerals from its inorganic sources is quite low so these minerals are added 20-30 fold higher than the normal requirement of animals which can lead to excess excretion of these minerals in the stool the stool resulting in environmental pollution Furthermore, it may affect the balance of other minerals. So, alternative like organic sources of minerals are studied which are having much higher bioavailability than inorganic sources of minerals however, organic sources of minerals are much costlier than traditional inorganic sources. Recently, it has been demonstrated that material at nano meter dimension exhibit novel properties different from its normal sized particles. such as, greater specific surface area, higher surface activity, high catalytic efficiency and stronger adsorbing ability which due to the advantage of size effect and high surface reactivity, nanoparticles are already use in pharmaceutical applications to increase the bioavailability of drugs and targeting therapeutic agents to particular organs. However, so far, very little information is available on the suitability and efficacy of nanoparticles of minerals in the diet of the animals.
Keywords: *Nano-Minerals, Animal nutrition*

Received 01.01.2017 Revised 15.01.2017 Accepted 08.02.2017

INTRODUCTION

Nanotechnology (from the Latin nanus, meaning dwarf) is defined as the technology of materials and structures where size is measured in nanometers, with application in diverse areas such as physics, chemistry, and biology [1]. This implies a certain understanding and control of matter measuring from 1 to 100 nm, with the capability of having new applications. This is because at sizes so small, the properties of matter can differ considerably from those at larger scale, even in microns. For a better understanding, a nanometer is a billionth of a meter (10^{-9}) [2] many biological structures are sized at a few nanometers like size of virus, protein, DNA and atom ranges from 75-100, 5-50, <2 and <1, respectively [3].Historically nanoparticles have existed on the planet for a very long period of time, and they have been created though several natural phenomena, including photochemical reactions, volcanic eruptions, or forest fires [1]. The applications of nanotechnology are indeed very varied. For example, it is used in electronics for the fabrication of processors, hard drives, and batteries; in ecology it is used to eliminate certain pollutants from the air and water; in the cosmetics industry it is used to make products such as sunscreen creams, make-up, hair dyes, and certain creams containing nanoparticles; there are even many industrial paints and lubricants containing these particles in order to obtain products with specific characteristics [1], such as "intelligent" packages that alert consumers if the product is somehow contaminated [4]; in agriculture it is used in the form of nanofertilizers, water catchers, and trappers of toxic substances [5]; and there are many other uses. Nevertheless, one of the most important and extensive uses of nanotechnology is in the area of human medicine, where it has allowed the development of nanoparticles for the controlled liberation of cancer medication [6], nutrients [7], hormones [8], gene therapy [9] and as a contrast medium for image studies [10], among others. In the area of veterinary medicine and animal production, there is a growing interest in the application of nanotechnology in its processes. However, research in this field is still very limited. Recently, it has been demonstrated that material at nano meter dimension exhibit novel properties different from its normal sized particles. Studies showed that nanoparticles of minerals have higher bioavailability, because of their novel characteristics, such as, greater specific surface area, higher surface activity, high catalytic efficiency and stronger adsorbing ability [11]. Due to the advantage of size effect and high surface reactivity, nanoparticles are already use in pharmaceutical applications to increase the bioavailability of drugs and targeting therapeutic agents to particular organs [12] It has been reported that nanoparticle showed new characteristics of transport and uptake and exhibit higher absorption efficiencies [13] and reaches deeper into the tissues. Also nano particles can translocate via the lymph system to the liver and spleen and deposited in these organs. However, so far, very little information is available on the suitability and efficacy of nanoparticles on the performance of animals and most of the studied regarding use of nanotechnology in animal nutrition is focused mainly to assess the effect of supplementation of nano particles of minerals in the diet of non-ruminants, as we know the bioavailability of inorganic sources of zinc is quite low and alternative like organic sources of minerals are studied which are having much higher bioavailability than inorganic sources of minerals[14] but the disadvantage with organic sources of minerals is that they are much costlier than traditional inorganic sources of minerals [15].

Zinc (Zn) nanoparticles supplementation on performance of animals

[15] reported that supplementation of 20 ppm nano zinc in broilers significantly improved weight gain, feed efficiency, total antioxidant capability and SOD and catalase activity as compared to control fed 60 ppm of zinc oxide. [16] conducted an experiment to study the effect of nano-zinc oxide on the production performance and dressing performance of broilers. They supplemented nano-zinc oxide at 0, 40, 80, 120 mg/ kg levels for 6 weeks. While average weight gain was comparable between the groups, feed/ gain ratio was significantly decreased in the 40 mg/kg nano-zinc oxide group. The slaughter percentage and half eviscerated percentage of the broiler with nano-zinc oxide were also significantly higher in the 40 mg/kg nano-zinc oxide group than the control group. [17] observed that supplementation of zinc nanoparticles significantly lowered LDL, TG and cholesterol level and increased HDL in broiler. [18] reported that total gain, average daily gain was significantly higher in the group supplemented 20 ppm commercial zinc nao particles as compared to other groups. However, SOD enzyme activity in the erythrocytes of guinea pigs was significantly higher in all the groups supplemented 20 zinc nano particles and organic zinc as compared to control. These studies appear to indicate a positive effect of nano sizeed zinc over the normal sized particles.

Copper (Cu) supplementation on performance of animals

[19] reported that supplementation of 50 ppm nano Cu significantly improved growth rate and Cu availability in piglets as compared to CuSO4 group. Significant improvement was also observed in the digestibility of crude fat and energy, levels of IgG, γ-globulin and total globulin protein, and SOD activity in these pigs. [20] observed significant increase in average daily and the contents of IgA, IgG, IgM , complement C3 and C4 in the broilers supplemented with 50, 100 and 150 ppm copper loaded chitosan nanoparticles (CNP-Cu). Thymus, spleen, and bursa of Fabricus indexes and the population of *Lactobacillus* and *Bifidobacterium* in cecal digesta were increased and the population of coliforms was decreased. Dietary supplementation of CNPCu increased serum total protein and albumin and decreased urea nitrogen. [21] further reported that supplementation of 100 mg/kg CNP-Cu in the diet of weaned piglets significantly increased average daily gain and feed intake and decreased feed/gain ratio and diarrhoea rate compared to control group, the amount of *Escherichia coli* in duodenum, jejunum and caecum were significantly decreased, the number of *Lactobacillus* in jejunum and caecum were increased and the amount of *Bifidobacterium* in duodenum and caecum were also increased. Moreover, the villous height of duodenum, jejunum, and ileum mucosa was significantly increased and the crypt depth was significantly decreased.

Iron (Fe) supplementation on performance of animals

[22] reported that the relative bioavailability and in vitro solubility of nanoparticles of Fe was significantly higher than its normal sized particle. [23] observed that the lifetime of the

enzymes trypsin and peroxidase increased dramatically, from a few hours to weeks, by attaching them to magnetic Fe nanoparticles. It has been suggested that this ability to enhance protein stability by interfacing them with nano materials may impact numerous biological processes such as digestion, metabolism and nutrient uptake.

Selenium (Se) supplementation on performance of animals

[24] reported that ADG, digestibility of crude protien, serum total protien and globulin, T3 level, GSH-Px, SOD and catalase activity in the erythrocytes, serum antibody titer on 21days post vaccination were significantly higher in guinea pigs supplemented 150 ppb of nano selenium as compared to organic and inorganic selenium. [25]also reported that serum GSHPx, SOD and CAT activities and retention of Se in whole blood, serum and some organs were highest in 0.3 ppm nano-Se supplemented goats, followed by selenoyeast and sodium selenite supplemented groups, respectively. [26] observed that supplementation of Se nanoparticles in layer birds at different doses (0.075, 0.15, 0.3, 0.6 ppm) resulted in significantly higher body weight, Se content in liver, breast muscle, pancreases and feathers compared to sodium selenite and control group.[27] observed that supplementation of Nano Se (0.2 and 0.5 ppm) and sodium selenite (0.2 ppm) to the avian broiler results in improved daily weight gain and survival rate and decreased feed conversion ratio, liver Se content and activity of GSH-Px enzyme as compared to control. [28] observed improved final BW, daily BW gain, feed conversion ratio and survival rate in 0.10, 0.30 and 0.50 ppm Nano Se supplemented Guangxi Yellow chicken compared to control group. The Nano-Se groups also showed higher hepatic and muscle Se contents, drip loss percentage, inosine 52 - monophosphate content, and GSH-Px activities in the serum and liver than control group. [29] observed that nano selenium ameliorate toxic effect induced by paracetamol in brain and kidney of rats by different mechanism like inhibition of malondialdehyde and nitric oxide concentrations or by increasing GSH concentration and significant decreasing the concentration of pro inflammatory cytokine TNF-α in these organs. Also DNA fragmentation % significantly decreased in the same organs.

Chromium (Cr) supplementation on performance of animals

[30] reported that supplementation of 500 and 3000 ppb nanoparticles chromium picolinate (NanoCrPic) in the diet of layer chicken for the period of 60 days had no effect on liver Cr, Ca, and P concentration. [31]found that supplementation of 0-400 ppb Cr loaded Chitosan nanoparticles (Cr-CNP) in the finishing pigs while had no effect on growth performance, decreased serum glucose, increased serum immunoglobulins A and M and serum complement 4 in a linear and quadratic manner. There was also linear increase in the chromium content in the blood, longissimus muscle, heart, liver, kidney, and pancreas. These findings suggested that dietary supplementation of Cr as Cr-CNP affect serum glucose, influences immune status, and increase the tissue chromium content of blood, muscle, and selected organs in finishing pigs. [32] reported that supplementation of 200 µg nano Cr in finishing pigs resulted in higher carcass lean percentage, larger longissimus muscle area, lower carcass fat percentage and lower back fat thickness. Drip loss in chops from pigs fed nano Cr was decreased by 21.5% and weights of longissimus and semimembranosus muscles were increased by 16 and 15 percent respectively. In addition, supplemental nano Cr resulted in 184, 145, 88 and 53 percent increment of Cr concentration in longissimus muscle, liver, kidney and heart, respectively, suggesting that supplemental nano Cr had beneficial effects on carcass characteristics and pork quality Similarly, [33] observed that supplementation of 200 µg chromium from CrNano/kg to the finishing pigs resulted in significantly higher serum level of total protein, HDL and lipase activity and reduced serum glucose, urea nitrogen, triglyceride, cholesterol and non-esterified fatty acid levels. [34] also reported higher serum Cr and HDL cholesterol level and lower VLDL cholesterol level in rats supplemented 300 ppb nano chromium picolinate (NanoCrPic) for 48 days as compared with rats fed Crpic or $CrCl_3$. Similarly, [35] reported that supplementation of 1200 ppb nano chromium picolinate (NanoCrPic) in broilers resulted in higher serum Cr level and lower serum LDL cholesterol and triglyceride level compared to Cr picolinate group. [36] Supplemented 150-450 ppb nano Cr to the diet of rats for 8 weeks and found that rats those received CrNano exhibited no changes in growth rate and food efficiency compared to the control group. However, dietary supplementation of 150, 300, and 450 ppb Cr from CrNano significantly decreased serum concentrations of insulin and cortisol, increased sera levels of insulin-like growth factor I and

immunoglobulin G, and enhanced the lymphoproliferative response, anti-SRBC PFC response, and phagocytic activity of peritoneal macrophages.

REFERENCES

1. Buzea, C., Blandino, I.I.P. & Robbie K. (2007). Nanomaterials and nanoparticles:Sources and toxicity. Biointerphases. 2(4): 17-172.
2. NNI. (2009).What is nanotechnology? National Nanotechnology Initiative.www.nano.gov/html /facts/whatIsNano.htm
3. Scott, N.R. (2005). Nanotechnology and animal health. Revue Scientifique et Technique. In. Office Epizootics. 24:425-432
4. ETC Group. (2004). La invasion invisible del campo.www.etcgroup.org/ upload/publication /82/02/invasin_campo.pdf .
5. Lal, R. (2007). Soil science and the carbon civilization. Soil Sci. Soc. Am. J. 71:1425-1437.
6. Sinha, R., Kim, G., Nie, S. & Shin, D. (2006). Nanotechnology in cancer therapeutics: bioconjugated nanoparticles for drug delivery. Mol. Cancer Ther. 5:1909-1917.
7. Ross, S.A., Srinivas, P.R., Clifford, A.J., Lee, S.C., Philbert, M.A. & Hettich, R.L. (2004). New technologies for nutrition research. J. Nutr. 134:681-685.
8. Schaffazick, S.R., Pohlmann, A.R., Mezzalira, G. & Guterres, S.S. (2006). Development ofnanocapsule suspensions and nanocapsulespray-dried powders containing melatonin. J. Braz. Chem. Soc.17:562-569.
9. Bowman, K. & Leong, K.W. (2006). Chitosan nanoparticles for oral drug and gene delivery. Int. J. Nanomed. 1:117-128.
10. McNeil, S. (2005). Nanotechnology for the biologist. J. Leukoc. Biol. 78:585-594.
11. Zhang, J. S., Gao, X. Y., Zhang, L. D. & Bao, Y. P. (2001). Biological effects of nano red elemental selenium. Biofactors, 15: 27-38.
12. Davda, J. & Labhasetwar, V. (2002). Characterization of nanoparticle uptake by endothelial cells. Int. J. Pharm. 233: 51–59.and absorption efficiency in Caco-2 cell monolayer. Food Chem. 119: 896–902.
13. Liao, C. D., Hung, W. L., Jan, K. C., Yeh, A. I., Ho, C. T. and Hwang, L. S. 2010. Nano/sub-microsized lignan glycosides from sesame meal exhibit higher transport and absorption efficiency in Caco-2 cell monolayer. Food Chem 119(3):896:902.
14. Sridhar, K., Nagalakshmi, D., Rao, D. S. & Rao, S.V. R. (2015). Effect of Supplementation of Graded Levels of Organic Zinc on Nutrient Utilization and Retention of Minerals in Broiler Chicken. Indian J. Anim. Nutr**.** 32(1): 80-85.
15. Zhao, Y. C., Shu, T. X., Xiao, Y. X., Qiu, S. X., Pan, Q. J. & Tang, X. Z. (2014). Effects of dietary zinc oxide nanoparticles on growth performance and antioxidative status in broiler. Biol. Trace Elem. Res. 160(3): 361-367.
16. Lien, T. F., Yeh, H. S., Lu, F. Y. & Fu, C. M. (2009). Nanoparticles of chromium picolinate enhance chromium digestibility and absorption. J. Sci. Food Agri. 89(7): 1164-1167.
17. Ahmadi, F., Ebrrahimnezhad, Y., Sis, M. N. & Ghalehkandi, J. G. (2013). The effects of zinc oxide nanoparticles on performance, digestive organs and serum lipid concentrations in broiler chickens during starter period. Int. J. Bio. Sci. 3(7): 23-29.
18. Uniyal, S. (2015). Effect of zinc nanoparticles supplementation on growth and health status of guinea pigs (*Cavia porcellus*). Thesis, M.V.Sc. Deemed University, Indian Veterinary Research Institute, Izatnagar, India. 70 p.
19. Gonzales-Eguia, A., Fu, C. M., Lu, F.Y. & Lien, T. F. (2009). Effects of nano copper on copper availability and nutrients digestibility, growth performance and serum traits of piglets Livest. Sci. 126: 122–129.
20. Wang, C., Wang, M. Q., Ye, S. S., Tao, W. J. & Du, Y. J. (2011). Effects of copper-loaded chitosan nanoparticles on growth and immunity in broilers. Poult. Sci. 90: 2223–2228.
21. Wang, M. Q., Du, Y. J., Wang, C., Tao W. J., He, Y. D. & Li, H. (2012). Effects of Copper-Loaded Chitosan Nanoparticles on Intestinal Microflora and Morphology in Weaned Piglets. Biol. Trace Elem. Res. DOI 10.1007/s12011-012-9410-0.
22. Rohner, F., Ernst, F.O., Arnold, M., Hilbe, M., Biebinger, R., Ehrensperger, F., Pratsinis, S. E., Langhans, W., Hurrell R. F. & Zimmermann, M. B. (2007). Synthesis, characterization and bioavailability in rats of ferric phosphate nanoparticles. J. Nutr. 137: 614-619.
23. Sharma, A., Qiang, Y., Antony, J., Meyer, D., Kornacki, P. & Paszczynski, A. (2007). Dramatic increase in stability and longevity of enzymes attached to mono dispersive iron nanoparticles. Magnetics, IEEE Transactions 43: 2418-2420.
24. Bunglavan, S. J. (2013). Effect of supplementation of selenium nano particles on growth and health status of guinea pigs. Thesis, PhD. Deemed University, Indian Veterinary Research Institute, Izatnagar, India. 140 p.
25. Shi, L., Xun, W., Yue, W., Zhang, C., Ren, Y., Shi, L., Wanga, Q., Yanga, R. & Lei, F. (2011). Effect of sodium selenite, Se-yeast and nano-elemental selenium on growth performance, Se concentration and antioxidant status in growing male goats, Small Rumin. Res. 96: 49–52.

26. Mohapatra, P., Swain R. K., Mishra, S. K., Behera, T., Swain, P., Behura, N. C., Sahoo, G., Sethy, K., Bhol, B. P. & Dhama, K. (2014). Effects of dietary Nano- Selenium supplementation on the performance of layer grower birds. Asian J. Anim. Vet. Adv. 9(10): 641-652.
27. Wang, Y. (2009). Differential Effects of Sodium Selenite and Nano-Se on Growth Performance, Tissue Se Distribution, and Glutathione Peroxidase Activity of Avian Broiler. Biol. Trace Elem. Res. 128: 184–190.
28. Zhou, X. & Wang, Y. (2011). Influence of dietary nano elemental selenium on growth performance, tissue selenium distribution, meat quality, and glutathione peroxidase activity in Guangxi Yellow chicken. Poult. Sci. 90: 680–686.
29. Mohammed, E. T. & Safwat, G. M. (2013). Assessment of the ameliorative role of selenium nanoparticles on the oxidative stress of acetaminophen in some tissues of male albino rats. Beni-Suef University. J. Basic Appl. Sci. 2(2), 80-85.
30. Sirirat, N., Lu, J. J., Hung, A. T. Y. & Lien, T. F. (2013). Effect of different levels of nanoparticles chromium picolinate supplementation on performance, egg quality, mineral retention, and tissues minerals accumulation in layer chickens. J. Agri. Sci. 5(2), 150.
31. Wang, M. Q., Du, Y. J., Wang, C., Tao W. J., He, Y. D. & Li, H. (2012). Effects of Copper-Loaded Chitosan Nanoparticles on Intestinal Microflora and Morphology in Weaned Piglets. Biol. Trace Elem. Res. DOI 10.1007/s12011-012-9410-0.
32. Wang, M. Q. & Xu, Z. R. (2004). Effect of chromium nanoparticle on growth performance, carcass characteristics, pork quality and tissue chromium in finishing pigs. Asian Aust. J. Anim. Sci. 17: 1118-1122.
33. Wang, M. Q., Xu, Z. R., Zha, L. Y. & Lindemann, M. D. (2007). Effects of chromium nanocomposite supplementation on blood metabolites, endocrine parameters and immune traits in finishing pigs. Anim. Feed Sci. Technol. 139: 69–80.
34. Lien, T. F., Yeh, H. S., Lu, F. Y. & Fu, C. M. (2009). Nanoparticles of chromium picolinate enhance chromium digestibility and absorption. J. Sci. Food Agri. 89(7): 1164-1167.
35. Lin, Y. C., Huang, J. T., Li, M. Z., Cheng, C. Y. & Lien, T. F. (2015). Effect of supplemental nanoparticle trivalent chromium on the nutrient utilization, growth performance and serum traits of broilers. J. Anim. Physiol. Anim. Nutr. 99(1): 59-65.
36. Zha, L., Zeng, J., Sun, S., Deng, H., Luo, H. & Li, W. (2009). Chromium (III) Nanoparticles Affect Hormone and Immune Responses in Heat-Stressed Rats. Biol. Trace Elem. Res. 129: 157–169.

CITATION OF THIS ARTICLE

S Uniyal, N. Dutta, M. Raza, S.K. Jaiswal, J.K. Sahoo, Ashwin K. Application of Nano Minerals in the Field of Animal Nutrition: A Review. Bull. Env. Pharmacol. Life Sci., Vol 6[4] March 2017: 04-08