In recent years, nanotechnology has gained much attention within the scientific community in many countries. Many companies specializing in the manufacture of new forms of nanomaterials have introduced poultry and livestock production systems in order to enhance the efficiency of animal production. Nano mechanism is no longer a connotation or notion for the modern scientist only, but it has overturned into a recent enabling technique over the years, with huge possible to transform the field of cultivation and domestic animal, so evolved in these fields can be conveyed to avian and animals offspring systems with the aim of increasing production efficiency and meeting human needs of quality poultry and animal products. As a result of the small size of nanoparticles, their passage is very fast through the walls of the gastrointestinal tract, creating many important effects in various body systems, which provides the opportunity for researchers to deal with nanomaterials by studying many veterinary fields, including production, reproduction, disease control, dealing with biological materials such as the study of DNA and cellular molecules.

**Objective:** this article aims to shed light on the available information regarding additives based on nanoparticles and to determine the possibility and importance of using compounds and nanomaterials as feed additives in animal diets.

**Keywords:** Nanotechnology, Poultry, Feed additives, Production, Livestock, Physiology.
be used as possible alternatives to feed additives instead of using antibiotics. In addition, the use of nanocomposites as feed supplements instead of larger particles reduces the excretion of metals [7], for example addition nanozinc oxide with a dose of 800 mg / kg in animal diets improves intestinal structure and daily growth rate [8].

*The physiological role of nanoparticles*
1- It increases the surface area of the compounds, allowing the opportunity for biological reactions
2- Extending the stay of compounds in the digestive system, which gives a wider scope for enzymatic reactions
3- Reducing the effect of the intestinal excretion mechanism, and gives a better period for the digestion and absorption process
4- Due to their small particles, they penetrate deeply into the tissues through the tiny capillaries
5- It passes through the epithelial lining organs such as the liver
6- Effective absorption by cells
7- Efficiency of the delivery of active compounds to the target organs in the body [3].

*Employment of nanotechnique in animal food*
Nanotechnique provides a wide field to veterinarians for treatment, diagnosis, tissue engineering, production of vaccines, and modern disinfectants, as it can be used in the domain of animal health, offspring, upbringing, and procreation [5]. Fig. 1. As a result of the small size of the nanoparticles, they reach the target cells more quickly, allowing the usage of very small doses, which results in reducing the residual compounds and dragging time in the tissues of livestock [4]. The produce of nanoparticles prepared many benefits for producing animal supplements with lower cost and concentrations. It can also aid control pathogens existing in the diet, regulate the rumen fermentation procedure, and outdo numerous sexual obstacles in animals [9]. Many nanoparticles are available for use commercially as feed supplements in animal food, for example, nano zinc oxide, which amelioration the growth rate, increases immunity and reproduction of livestock and poultry [10]. Rajendran et al.[11] indicated an increase in milk production in infected dairy cows with mastitis when treated with nano zinc oxide.

![Fig. 1. Employment of nanotechnique in animal food][12].
The role of nanocomposites in amelioration ecosystem in poultry

The effectiveness and efficiency of the intestine in poultry depends greatly on food, the intestinal mucosa is characterized by its containment of finger-like protrusions called villi that increase the surface area of absorption [13]. The internal mucosa and the villi length play a critical role in the absorption process if the villi length is directly proportional to the absorption of the digested material [14]. Several studies have indicated the importance of nanocomposites in improving the internal environment of the intestine in poultry, as Ahmadi et al. [15] indicated that the addition of nano zinc at a rate of 60 mg/kg feed to broiler diets led to an increase in villi length during the growth stage. Where the nanoparticles work to maintain the integrity of the intestinal epithelium and reduce the loss of cells [16]. The importance of nanoparticles also lies in improving the internal environment of poultry by increasing the number of goblet cells, which are characterized by the secretion of mucus, which forms a barrier that protects the intestinal walls. Sultan et al [17] indicated that the use of nanoparticles in chicken diets led to an elevated in the number of these cells. The acidic mucous secretions of these cells have a protective role for the intestinal mucosa against many pathogens and facilitate the movement of digested nutrients as a result of reducing the viscosity of these substances, which leads to an increase in the immune response of the birds [18]. These positive effects and the immune stimulation of nanoparticles are due to the smallness of its size and ability to penetrate the intestinal mucosa more easily compared to large particles. The importance of nanoparticles also lies in reducing heat stress in poultry, as Abbasi et al. [19] indicated that adding 0.5% silver nanoparticles to the broiler ratio improved the number of beneficial microbes in the gut exposed to heat stress. Fig.(2) can summarize the important role of nanomaterials in chickens.

Fig. 2. Role of nanomaterials in chickens[20].

The function of nanocompounds in the ruminal fermentation

The rumen is a complex ecosystem in which the consumed nutrients are digested anaerobically by microorganisms such as bacteria and fungi and the final product of food fermentation is VFAs, which are used by the host ruminants. The relation between the beneficial bacteria and the host animal results in an equivalent relevance that permits ruminants to digest fiber-affluent and minimal-protein materials [21]. The fermentation process in the rumen is highly inefficient because it produces some final compounds like methane and ammonia [22]. For the purpose of improving the efficiency of microbial digestion, many food systems have been followed to change the...
path of microbial digestion in a way that serves
the efficiency of the digestive process without
affecting the health and productivity of the animal
[23], in order to achieve this goal, the employed
of minerals in the diet of animals has been
directed towards, including nanoscale minerals
because of their importance in improving the
digestion process due to their small particles and
 provision of a large surface area. Hassan et al.[24]
indicate that the addition of nanozinc at dose 20
mg/kg feed led to reduced methane production
and improved level of antioxidants. This positive
effect of nanoparticles by reducing the level of
methane gas can be attributed to reducing the
numbers of bacteria producing it or re-directing
the hydrogen flow to bind to the receptors for
producing propionate [25]. The positive effect
of these minerals also lies in their improvement of
some digestive enzymes in the alimentary channel
[26].

The importance of nanoparticles in horse nutrition

There are many problems facing horse
breeding, including digestive disorders, toxic
pollutants for feed, bacterial and fungal infections
[27]. Therefore, the current trend has been to
use nanoparticles as feed supplements in equine
breeding farms instead of antibiotics because of
their positive effects on control many diseases,
improving the daily growth rate and the efficiency
of the digestive process, the challenge of using
this technique lies in the ability of its molecules
to analyze many pathogens in the alimentary tract
[28]. Pathological conditions of the digestive
system, especially the problem of diarrhea in
foal, are among the most important obstacles to
growth and have negative effects on the process
of assimilation of digested material [29], where
Tiwari et al.[30] indicated that the use of nano
zinc at a dose of 800 mg/kg in horse diets led
to a decrease in the incidence of diarrhea and a
significant increase in the daily growth rate of the
foal. These compounds had significant effects in
inducing changes in the composition of the gut as
Moyosore et al.[31] indicated that the supplement
of nanoscale zinc results in a significant rise in
the length, width, and surface area of villi, leading
to improved digestion and absorption of nutrients.
Nano food reduces gut fermentation disorders [32].
Research conducted by Saware et al.[33] indicates
an increase in the effectiveness of digestive
enzymes, especially the α- amylase when using
silver and gold nanoparticles in horse food, and
this explains the mechanism of the action of these
particles in increasing the breakdown of starch to
reduce the level of sugar in the large intestine and
thus reduce fermentation disorders in the cecum.
Increasing the effectiveness of some enzymes
such as trypsin and peroxidase can last for several
weeks instead of several hours when combined
with nanomaterial like iron nanoparticles [34],
which helps in improving the metabolic efficiency
and digestion of the substances ingested in horses.
The mechanism of action of nanocomposites in
horses can be summarized as shown in Fig. 3.

Fig. 3. Nanotechnique in horse nutrition [31].

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Conclusion

We conclude from this article that the nanotechnology mechanism can be applied in the production of nanocomposites that can be used to improve digestion and absorption in farm animals as ingredients or new feed additives while improving the quality of nutrients. Nanotechnology is still in continuous development to this day, with the aim of improving animal production. Studies in this area are still very limited. Nanocomposites should be incorporated into animal nutrition research that could significantly enhance animal growth and production efficiency with minimal risks to consumers. However, a great deal of research is still needed to support the efficacy, primarily the safety of nanotechnology, and the avoidance of any harm to animals, humans, and the surrounding environment.

Acknowledgement

This review was funded by the College of Veterinary Medicine, University of Mosul, Mosul, Iraq.

Conflict of Interest

This is a review article, no conflict of interest.

References

1. Hameed, H.M., Tawfeek, F.K. and Adul-Rhaman, S.Y. Effect of β-mannanase, Lysolecithin and probiotic on some reproductive performance and hormone profile in female quail. *Iraqi Journal of Iraqi*, 34(1), 87-93(2020).

2. Maty, H.N. and Hassan, A.A. Effect of supplementation of encapsulated organic acid and essential oil Gallant+® on some physiological parameters of Japanese quails. *Iraqi. J. Vet. Sci.*, 34, 181-188(2019).

3. Surej Joseph Bunglavan1, A.K., Garg, R.S., Dass and Sameer Shrivastava.Use of nanoparticles as feed additives to improve digestion and absorption in livestock.*Livestock Research International.*, 3, 36-47(2014).

4. Troncarelli, M.Z., Brandão, H.M., Gern, J.C., Guimarães, A.S and Langoni,H. *Nanotechnology and Antimicrobials in Veterinary Medicine*, 1, 543-556(2013).

5. Manuja,A., Kumar, B and Singh, R.K. Nanotechnology developments: opportunities for animal health and production. *Nanotechnol. Dev.*, 2, 4-8(2012).

6. Ravi Kanth Reddy, P., Duvvuri Vasuswini, P. Pandu Ranga Reddy, Mohamed Zeineldin, M.J. Adegbeye and Iqbal Hyder. Applications, challenges, and strategies in the use of nanoparticles as feed additives in equine nutrition. *Veterinary World*, 13(8), 1685-1696 (2020). *EISSN*, 2231-0916

7. Gopi, M., Pearlin, B., Kumar, R.D., Shanmathy, M. and Prabakar,G. Role of nanoparticles in animal and poultry nutrition: Modes of action and applications in formulating feed additives in food processing. *Int. J. Pharmacol.*, 13(7),274-731(2017).

8. Wang, C., Zhang, L., Ying, Z., He, J., Zhou, L., Zhang, L., Zhong, X. and Wang, T. Effects of dietary zinc oxide nanoparticles on growth, diarrhea, mineral deposition, intestinal morphology, and barrier of weaned piglets. *Biol. Trace Elem. Res.*, 185(2), 364-374(2018).

9. Marappan Gopi., Beulah Pearlin., Ramasamy Dhinesh Kumar., MuthuvelShanmathy and GovindasamyPrabakar. Role of Nanoparticles in Animal and Poultry Nutrition: Modes of Action and Applications in Formulating Feed Additives and Food Processing. *International Journal of Pharmacology.*, 13(7),724-731(2017).

10. Swain, P.S, Rajendran, D., Rao, S.B., Dominic, G. Preparation and effects of nano mineral particle feeding in livestock: a review. *Vet. World*, 8, 888-891(2015).

11. Mishra, A., Swain, R., Mishra, S., Panda, N., Sethy, K. Growth performance and serum biochemical parameters as affected by nano zinc supplementation in layer chicks. *Indian J. Anim. Nutr.*, 31, 384-388(2014).

12. Rajendran, D. Application of nano minerals in animal production system. *Res. J. Biotechnol.*, 8, 1–3(2013).

13. Yazdani, A., Poorbaghi, S.L. and Habibi H. Dietary Berberis vulgaris extract enhances intestinal mucosa morphology in the broiler chicken (Gallus gallus). *Comp. Clin. Path.*, 22, 611-615 (2013).

14. Lei, X.J., Ru, Y.J. and Zhang, H.F. Effect of Bacillus amyloliquefaciens-based direct-fed microbials and antibiotic on performance, nutrient digestibility, cecal microflora, and intestinal morphology in broiler chickens. *J. Appl. Poult. Res.*, 23, 1-8(2014).

*Egypt. J. Vet. Sci. Vol. 52*, No. 3 (2021)
15. Ahmadi, F., Ebrahimnezhad, Y., Sis, N.M. and Ghiasi, J. The effects of zinc oxide nanoparticles on performance, digestive organs and serum lipid concentrations in broiler chickens during starter period. *Int. J. Biosci.*, 3, 23-29(2013).

16. Hu, C.H., Gu, L.Y., Luan, Z.S. Effects of montmorillonite–zinc oxide hybrid on performance, diarrhea, intestinal permeability and morphology of weanling pigs. *Anim. Feed Sci. Technol.*, 177,108-115(2012).

17. Sultan Ali., Saima Masood., Hafsa Zaneb., Hafiz Faseeh-ur-Rehman., SabiqaaMasood., Muti-ur-Rehman Khan., Sajid Khan Tahir and Habibur Rehman. Supplementation of Zinc Oxide Nanoparticles has Beneficial Effects on Intestinal Morphology in Broiler Chicken. *Pakistan Veterinary Journal*, 37(13), 1-5 (2017). https://www.researchgate.net/publication/319481090 ISSN, 0253-8318, 2074-7764

18. Duritis, I. and Mugurevics, A.Distribution and Characterization of Goblet Cells in the Large Intestine of Ostriches during the Pre-and Post-Hatch Period. *Anat. Histol. Embryo.*, 145,457-462(2015).

19. Abbasi, S.R., Hashemi, S., Hassani, M. and Ebrahimi. Gastrointestinal Microbial Population Response and Performance of Broiler Chickens Fed with Organic Acids and Silver Nanoparticles Coated on Zeolite under Heat Stress Condition. *Iranian Journal of Applied Animal Science.*, 8(4) 685-691(2018)

20. Amlan Pataaand Melody Lahlriatpuii. Progress and Prospect of Essential Mineral Nanoparticles in Poultry Nutrition and Feeding—A Review. *Biological Trace Element Research*, 197, 233–253(2020).

21. Castillo-González, A.R., Burrola-Barrazab, J.,Dominguez-Viveros, A and Chávez-Martinezb. Rumen microorganisms and fermentation. *Arch. Med. Vet.*, 46, 349-361(2014).

22. Kingston-Smith, A.H., Marshall, A.H and Moorby, J.M. Breeding for genetic improvement of forage plants in relation to increasing animal production with reduced environmental footprint. *Animal Production*, 1,1-10(2012).

23. Wu, G. Principles of Animal Nutrition. 1st ed. Boca Raton, FL, USA: Taylor & Francis Group (2018).

24. Hassan Riazi, Javad Rezaei and Yousef Rouzbeh. Effect of supplementary nano-ZnO on in vitro ruminal fermentation, methane release, antioxidants, and microbial biomass. *Turk. J. Vet. Anim. Sci.*, 43, 737-746(2019)

25. Sarker, N.C., Keomanivong, F., Borhan, M., Rahman, S. and Swanson,K.In vitro evaluation of nano zinc oxide (nZnO) on mitigation of gaseous emissions. *Journal of Animal Science and Technology*, 60(1), 27-32(2018).

26. Adegbeye, M.J., Elghandour, M.M., Barbabosa-Pliego, A., Monroy, J.C. and Mellado, M. Nanoparticles in equine nutrition: mechanism of action and application as feed additives. *Journal of Equine Veterinary Science*, 78 (1), 29-37(2019).

27. Bai, D.P., Lin, X.Y., Huang, Y.F. and Zhang, X.F. Theranostics aspects of various nanoparticles in veterinary medicine. *Int. J. Mol. Sci.*, 19:1e32(2018).

28. Xie, Y., Liu, Y., Yang, J., Liu, Y., Hu, F. and Zhu, K. Gold nanoclusters for targeting methicillin-resistant Staphylococcus aureus in vivo. *Angew. Chem. Int. Ed. Engl.*, 57(15), 3958-3962 (2018).

29. Mallicote, M., House, A.M. and Sanchez, L.C.A review of foal diarrhea from birth to weaning. *Equine Vet. Educ.*, 24(4), 206-214(2012).

30. Moyosore, J., Adegbeye, A., Mona, M.M.Y., Elghandour, B., Alberto Barbabosa-Pliego, B., Jose CedilloMonroy, C., Miguel Mellado, D., Poonooru Ravi Kanth Reddy, E., Abdelfattah, Z.M. and Salem,B.Nanoparticles in Equine Nutrition: Mechanism of Action and Application as Feed Additives. *Journal of Equine Veterinary Science*, 78,29e37(2019)

31. El Sabry, M.I., McMillin, K.W and Sabliov, C.M. Nanotechnology considerations for poultry and livestock production systems e a review. *Ann. Anim. Sci.*,18, 319e34(2018).
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33. Saware, K., Aurade, R.M., Jayanthi, P.D.K. and Abbaraju, V. Modulatory effect of citratereduced gold and biosynthesized silver nanoparticles on α-Amylase activity. *J. Nanoparticles*, 2(1),9 pages (2015). Article ID 829718, https://doi.org/10.1155/2015/829718

34. Deka, J., Paul, A. and Chattopadhyay, A. Modulating enzymatic activity in the presence of gold nanoparticles. *RSC Adv.*, 2,4736e45(2012).

33. Saware, K., Aurade, R.M., Jayanthi, P.D.K. and Abbaraju, V. Modulatory effect of citratereduced gold and biosynthesized silver nanoparticles on α-Amylase activity. *J. Nanoparticles*, 2(1),9 pages (2015). Article ID 829718, https://doi.org/10.1155/2015/829718

34. Deka, J., Paul, A. and Chattopadhyay, A. Modulating enzymatic activity in the presence of gold nanoparticles. *RSC Adv.*, 2,4736e45(2012).

PHYSIOLOGICAL ROLE OF NANOTECHNOLOGY IN ANIMAL AND POULTRY NUTRITION

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In recent years, nanotechnology has attracted significant interest among scientists in many countries. Numerous companies specializing in producing new shapes of nanomaterials that have been designed to improve the production of poultry and livestock, aiming to enhance animal productivity. Nanotechnology is not just a concept or theory for the world of science, but it has become a new enabled technology over the years, with tremendous potential to cause revolution in the fields of agriculture and animal husbandry, thus transferring the developments in these fields applied to poultry and livestock production systems to enhance production efficiency and meet the human need for quality poultry products. Since the nanomaterial particles are very small, they pass easily through the digestive tract and can cause many important effects in different body organs, providing researchers the opportunity to study many areas of veterinary medicine such as production, reproduction, disease control, and handling biological materials, such as DNA and cell particles. This paper aims to highlight the information available on the addition of nanomaterial particles and determine the possibility and importance of using the nanomaterial compounds in animal nutrition in the livestock industry.