Scientific Papers. Series D. Animal Science. Vol. LXIII, No. 2, 2020
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

SOME ADDITIVES USED IN POULTRY INDUSTRY FOR ALLEVIATE HEAT STRESS

Teodor GAVRIS*, Elena Narcisa POGURSCHI, Iuliana Stefania BORDEI, Dumitru DRAGOTOIU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: teogavris@gmail.com

Abstract

Due to climate change, thermal stress is becoming more common in poultry. Thermal stress causes changes in the metabolism of birds which is observed in their productive performance. Also, with the appearance of thermal stress and the decrease of the productive performances leads to important economic losses for the producers, but also for the consumers due to the decrease of the products quality. In this review are presented some changes that occur in the body of birds and some methods to alleviate heat stress. Among the cheapest methods of alleviate heat stress is the manipulation of diet. Among these unconventional additives we can mention vitamin A, vitamin E, dehydrated tomato peels and prebiotics such as inulin. Also, the use of unconventional additives in food is much easier to apply, requiring no investment in production facilities.

Key words*: heat stress, oxidative stress, poultry heat stress.*

INTRODUCTION

Heat stress is one of the important obstacles in poultry production. Poultry are the most sensitive heating stresses among all animals, due to its reduced ability to dissipate heat. Therefore, the high ambient temperature adversely affects the production and health of poultry. The importance of animal responses to environmental challenges applies to all species. Heat stress occurs when there is an imbalance between the net amount of energy flowing from the body of the animal in the environment and the amount of thermal energy produced by the animal. (Lara and Rostagno, 2013). Due to its perception, stress, a response to adverse stimuli, is difficult to understand. Stress is the body's nonspecific response to any request (Selye, 1976). Studies conducted so far show that the optimum temperature for hens farming is approximately 20ºC to 25ºC (Tumova and Gous, 2012). After exceeding the temperature of 30ºCelsius, the thermal stress is installed on the poultry (Yardibi and Hoştürk, 2008). When poultry live in a very hot environment they put a lot of effort to maintain their body temperature. In order to maintain their body temperature, the visceral organs function under a greater heat load. As a result of stress, the mortality rate increases, weight gain decreases, feed consumption decreases, and meat quality is also impaired. In the case of laying hens, the thermal stress leads to a decrease in the laying rate and a depreciation of the shell (Lin et al., 2006). Heat stress lead to metabolic and hormonal changes, secretion of inflammatory markers (Etches et al., 2008). It is well know that heat stress disturbs the balance of intestinal microflora, implicitly decreases nutrient digestibility and absorption, leading to a lower feed intake and body weight gain (Feng et al., 2012).

There is increasing evidence that heat stress can have a significant detrimental effect on food, due to a variety of mechanisms but the mechanisms underlying this effect have not been fully elucidated (Rostagno, 2009). Under conditions of high ambient temperature the poultry reduce the feed intake to decrease heat stress, which negatively affects the production performance. Nutritional management is one of simplest and most direct methods used in poultry production to attenuate the adverse effects of heat stress (Sahin et al., 2009). In last years, plants have come back to people's attention for various reasons (Trifunschi et al., 2017), some of them may be the only treatment for some incurable diseases for this time. Another reason why plants have returned to human attention would be that drugs can have in addition to the active substance and other chemicals that can have adverse effects on human or animal health. As a result of these observations, both in medicine and in the pharmaceutical industry, several plants could be used for curative purposes (Muntean et al., 2017). Many natural compounds such as herbs have been used in animal feed and have shown positive effects on growth performance and various health parameters. Many studies show that the use of herbs leads to a reduction in heat stress, such as: oregano, ginger, Artemisia annua (Panaite et al., 2018; Habibi et al., 2014; Turcu et al., 2018, Marin et al., 2015).The aim of this paper is to provide an presentation of published data on the general applications of herbs or active compounds on the harmful impact of heat stress on the poultry industry.

MATERIALS AND METHODS

Information about heat stress in poultry was obtained from a literature search of electronic databases on oxidative stress, alleviate heat stress, laying hens and broilers reared in high temperature, additives used in poultry diets for to combat effects of thermal stress.

RESULTS AND DISCUSSIONS

Physiological and behavioral effects of thermal stress on poultry:

In conditions of high temperature, birds change their behaviour, this being a reaction of the thermoregulation system that seeks a solution to lower the temperature. Mack, 2013 showed that birds reared in heat conditions spend less time feeding, more time drinking, as well as more time with raised wings, less time moving and more time resting. In order to maintain their thermoregulation and homeostasis when are reared in high ambient temperatures, animals use several adaptation systems such as vasodilation and perspiration (Mutaf et al., 2009). Unlike other animals, birds have an additional thermoregulatory system. The presence of air sacs is very useful during respiration because it promotes air circulation on surfaces thus contributing to increased gas exchange with the environment, and, consequently, heat loss through evaporation (Fedde et al., 1998). Research has shown that heat stress increases the plasma concentration of corticosterone and reduces the level of circulating thyroid hormones (Garriga et al., 2006). It has been found that the enteric nervous system and the central nervous system are connected bidirectionally through the autonomic nervous system, forming an axis between the digestive system and the brain (Eutamene and Bueno, 2007). With the appearance of thermal stress, large amounts of ROS are produced by mitochondria, affecting the energy generation efficiency and implicitly the damage of proteins, lipids and DNA. The mitochondrial membrane is predominantly composed of polyunsaturated fatty acids and proteins, they are particularly affected by oxidative stress (Akbarian et al., 2016).

Below are presented several additives for alleviate heat stress in poultry.

Probiotics used for alleviate heat stress

Sohail (2010) showed that the use of mannan-oligosaccharides and the probiotic-based *Lactobacillus* spp. for 42 day can reduce some of the harmful effects of cyclic heat stress on broilers. Among these improvements we can mention decrease serum cortisol and cholesterol concentrations and increased thyroxine concentration.

Inulin, like other probiotics such as acidifiers, bacteriocins and some phytobiotics support the homeostasis of the digestive system. A probiotic is a selective ferment for certain ingredients of feed, having beneficial effects on the host, acting on one or more beneficial microorganisms that populate the digestive system. In general, probiotics are not digestible by the host organism due to the fact that there is no enzymatic equipment to allow this activity (Gibson et al., 2004). Inulin is one of the most widely used probiotics today (Dankowiakowska et al., 2013). Inulin is a carbohydrate found in many plants. It is found in fruits and vegetables, for example chicory, Jerusalem artichoke, artichoke, onion, asparagus, but also in the stem of cereals such as wheat. The intestinal microflora plays a special role in the optimal functioning of the gut and implicitly acts positively on the health of the whole organism. (Miremadi and Shah, 2012). The use of inulin up to 2% in the food of laying hens helps to increase the number of beneficial bacteria such as Lactobacillus, helping to improve the rate of food conversion and weight gain. Also, as the number of bacteria in the genus Lactobacillus increases, the absorption of nutrients increases (Wu et al., 2019).

Vitamins used for alleviate heat stress

Regarding the reduction of the negative effects of stress on broiler chicks, vitamin E and vitamin A are used in the diet of poultry, due to the reported benefits of supplementation with vitamin E and vitamin A in birds raised under high thermal stress. This study shows that after the inclusion of 250 mg of vitamin E and 15000 IU of vitamin A per kg of feed for 6 weeks led to a decrease in products such as, MDA in serum and liver, resulting from exposure to heat stress. (Sahin et al., 2001). The use of vitamin E and vitamin A in the feed of chickens raised in thermal stress has led to an increase in the amount of vitamin E in the blood and liver, while also leading to a decrease in the concentration of malondialdehyde (MDA). Also after the additional administration of vitamin E the amount of minerals was affected. Serum copper concentration decreased linearly while, iron and zinc concentrations increased linearly when dietary vitamin E supplementation increased (Sahin et al., 2009).

Minerals used for alleviate heat stress:

Another study showed that using for 6 weeks, separately or together vitamin A and zinc lead to lower concentration of MDA serum, improved feed efficiency and carcass traits. Also supplementing diets with vitamin A (4.5 mg/kg diet) and zinc (30 mg Zn/kg diet) offers a protective potential in preventing the effects of thermal stress on the performance of broiler chickens (Kucuk et al., 2003). Using of 100 mg/kg of Zn decrease mortality and increase activity of the activity of antioxidant enzymes (Ismail et al., 2013).

Using chromium picolinate supplements (up to 800 μ/kg of diet) in poultry feed has been shown a lower cholesterol and glucose concentrations in serum. Chromium is essential for normal glucose metabolism and is a component of the glucose tolerance factor, which works with insulin to move glucose into cells for energy generation (Pogurschi et al., 2019). As the amount of insulin increases, so does the use of glucose, which leads to an improvement in live weight gain, feed efficiency and carcass quality (Sahin et al., 2002).

Another way to combat heat stress, implicitly oxidative stress is to use dietary supplements with antioxidants from plants.

Phenolic compounds present in plants possess antioxidant effects that prevent chronic cardiovascular diseases (Forester and Waterhouse, 2009). These health effects are reported due to the antiradical and antioxidant properties of plant phenolics and plant derivatives (Lurton, 2003).

Some studies show that the use of lycopene in the diets of broiler chickens helps to improve the health of animals. Using lycopene supplements, antioxidant enzyme levels increased and MDA levels decreased in meat and serum (Sahin et al., 2016). A real source of lycopene are dried tomato peels. Lycopene is a non-provitamin A carotenoid which is a powerful antioxidant that provides protection against damage to the cells due to free radicals with a singlet-oxygen-quenching ability (Palozza et al., 2012). The inclusion of 5% dried tomato fruit for 42 days in the diet of broiler chickens raised in heat stress leads to a decrease in HDL cholesterol and triglycerides and an increase in superoxid dismutase (SOD) and glutathione peroxidase (GPx) activity, while the concentration of MDA decreased (Hosseini-Vashan et al., 2016). .

Table 1. Effects of some additives used in poultry for alleviate heat stress

Feed additive	Inculsion	Effects	Reference
Prebiotics and probiotics			
Mannan-oligosaccharides and *Lactobacillus* spp.	0.50%	decrease serum cortisol and cholesterol	Sohail et al., 2010
Vitamins			
Vitamin A	15000 UI/kg of feed	decrease glucose, cholesterol, triglycerides in serum	Sahin et al., 2001
Vitamin E	250 mg/kg of feed		
Vitamin A	4.5 mg/kg of feed	decrease MDA concentration, improve feed efficiency and carcass traits	Kucuk et al., 2003
Zinc	30 mg/kg of feed		
Minerals			
Chromium picolinate (CrPic)	up to 800 µg//kg of feed	decrease serum corticosterone concentration; decreased concentration of glucose and cholesterol in serum concentrations; increased serum insulin concentration.	Sahin et al., 2002
Zinc	100 mg/ kg	increase antioxidant enzyme levels and decrease mortality	Ismail et al.,2013
Plants / plants extracts			
Lycopene	400 mg/kg	increase antioxidant enzyme levels and decrease MDA in serum and meat	Sahin et al., 2016
Tomato peel (dryed)	5%	decrease in HDL cholesterol, triglycerides and MDA in serum; increase superoxid dismutase (SOD) and glutathione peroxidase (GPx) activity.	Hosseini-Vashan et al., 2016
Mulberry Leaf Extract	0.5%	decrease MDA concentration in serum	Gundogdu et al., 2011
Resveratrol	400 mg/kg	decrease MDA concentration in serum; increase egg laying	Sahin et al., 2022

Mulberry Morus is a plant used in traditional medicine for its beneficial effects. The leaves of this plant contain phenolic compounds which has an antioxidant effect (Gundogdu et al., 2011). Mulberry Leaf has been shown to efficiently annihilate free radicals such as NO, superoxides and 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radicals. Following the administration of mulberry leaves to laying hens for 12 weeks, the amount of MDA in the serum was lower. With the improvement of the health of the hens, the weight of the shell and its breaking strength increased (Lin et al., 2017).

Inclusion of resveratrol in the diet of laying hens for 12 weeks, led to increased liver antioxidant activity. The amount of MDA also decreased while the percentage of eggs was higher when 400 mg/kg of feed was administered (Sahin et al., 2012).

Al-Juhaimi (2011) showed that parsley contains significant amounts of polyphenols in its composition, thus having beneficial effects on the body due to their antioxidant effect.

CONCLUSIONS

In conclusion, thermal stress causes significant economic losses for meat and egg producers. Some minerals such as chromium, zinc help reduce oxidative products and thus heat stress. There are natural compounds that are easily accessible and can reduce the effects of heat stress.

ACKNOWLEDGEMENTS

This research work was a part from PhD thesis ”Research on the negative effects of thermal stress on oxidative processes in monogastrics and their control by using unconventional feed additives in diet” elaboration and was carried out with the support of Faculty of Engineering and Management of Animal Production, University of Agronomic Sciences and Veterinary Medicine of Bucharest.

REFERENCES

Akbarian, A., Michiels, J., Degroote, J., Majdeddin, M., Golian, A., De Smet, S. (2016). Association between heat stress and oxidative stress in poultry; mitochondrial dysfunction and dietary interventions with phytochemicals. *Journal of Animal Science and Biotechnology,* 7(1), 37.

Al-Juhaimi, F., Ghafoor, K. (2011). Total phenols and antioxidant activities of leaf and stem extracts from coriander, mint and parsley grown in Saudi Arabia. *Pak. J. Bot*, 43(4), 2235-2237.

Dankowiakowska, A., Kozłowska, I., Bednarczyk, M. (2013). Probiotics, prebiotics and snybiotics in Poultry–mode of action, limitation, and achievements. *Journal of Central European Agriculture*, 14(1), 467-478.

Etches, R., John, J.M., Gibbins, A.M.V. (2008) Behavioural, physiological, neuroendocrine and molecular responses to heat stress, in: DAGHIR, N.J. (Ed.) Poultry Production in Hot Climates, Second Edition, pp. 48-79 *(CAB International, Wallingford, UK).*

Eutamene, H., Bueno, L. (2007). Role of probiotics in correcting abnormalities of colonic flora induced by stress. *Gut*, 56(11), 1495-1497.

Fedde, M. R. (1998). Relationship of structure and function of the avian respiratory system to disease susceptibility. *Poultry science*, 77(8), 1130-1138.

Feng, Y., Yang, X. J., Wang, Y. B., Li, W. L., Liu, Y., Yin, R. Q., Yao, J. H. (2012). Effects of immune stress on performance parameters, intestinal enzyme activity and mRNA expression of intestinal transporters in broiler chickens. *Asian-Australasian journal of animal sciences*, 25(5), 701.

Forester, S. C., Waterhouse, A. L. (2009). Metabolites are key to understanding health effects of wine polyphenolics. *The Journal of nutrition*, 139(9), 1824S-1831S.

Garriga, C., Hunter, R. R., Amat, C., Planas, J. M., Mitchell, M. A., Moretó, M. (2006). Heat stress increases apical glucose transport in the chicken jejunum. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 290(1), R195-R201.

Gibson, G. R., Probert, H. M., Van Loo, J., Rastall, R. A., Roberfroid, M. B. (2004). Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. *Nutrition research reviews*, 17(2), 259-275.

Gundogdu, M., Muradoglu, F., Sensoy, R. G., Yilmaz, H. (2011). Determination of fruit chemical properties of *Morus nigra* L., *Morus alba* L. and *Morus rubra* L. by HPLC. *Scientia Horticulturae*, 132, 37-41.

Habibi, R., Sadeghi, G. H., Karimi, A. (2014). Effect of different concentrations of ginger root powder and its essential oil on growth performance, serum metabolites and antioxidant status in broiler chicks under heat stress. *British poultry science*, 55(2), 228-237.

Hosseini-Vashan, S.J., Golian, A., Yaghobfar, A. (2016). Growth, immune, antioxidant, and bone responses of heat stress-exposed broilers fed diets supplemented with tomato pomace. *International Journal of Biometeorology*, 60, 1183-1192.

Ismail, I. B., Al-Busadah, K. A., El-Bahr, S. M. (2013). Oxidative stress biomarkers and biochemical profile in broilers chicken fed zinc bacitracin and ascorbic acid under hot climate. *Am J Biochem Mol Biol*, 3, 202-214.

Kucuk, O., Sahin, N., Sahin, K. (2003). *Supplemental zinc and vitamin A can alleviate negative effects of heat medicinale cultivate şi spontane*. https://pubmed.ncbi.nlm.nih.gov/12972690/

Lara, L. J., Rostagno, M. H. (2013). Impact of heat stress on poultry production. *Animals*, 3(2), 356-369

Lin, H., Decuypere, E., Buyse, J. (2006). Acute heat stress induces oxidative stress in broiler chickens. Comparative Biochemistry and Physiology Part A. *Molecular & Integrative Physiology*, 144(1), 11-17.

Lin, W. C., Lee, M. T., Chang, S. C., Chang, Y. L., Shih, C. H., Yu, B., Lee, T. T. (2017). Effects of mulberry leaves on production performance and the potential modulation of antioxidative status in laying hens. *Poultry science*, 96(5), 1191-1203.

Lurton, L. (2003). Grape polyphenols: New powerful health ingredients. *Innovations in Food Technology*, 18, 28-30.

Mack, L. A., Felver-Gant, J. N., Dennis, R. L., Cheng, H. W. (2013). Genetic variations alter production and behavioral responses following heat stress in 2 strains of laying hens. *Poultry science*, 92(2), 285-294.

Marin, M., Drăgotoiu, D., Nicolae, C. G., Diniţă, G. (2015) Research on the influence of the oregano oil use over the productive performances and quality of duck meat. *AgroLife Scientific Journal*, 4 (2), 48-51.

Miremadi, F., Shah N.P. (2012). Applications of inulin and probiotics in health and nutrition. *International Food Research Journal*, 19, 1337-1350.

Mutaf, S., Seber Kahraman, N., Firat, M. Z. (2009). Intermittent partial surface wetting and its effect on body-surface temperatures and egg production of white and brown domestic laying hens in Antalya (Turkey). *British poultry science*, 50(1), 33-38.

Muntean, L. S., Tămaș, M., Muntean, S., Muntean, L., Duda, M., Vârban, D., Florian, S. (2017). *Treatise on cultivated and spontaneous medicinal plants / Tratat de plante medicinale cultivate şi spontane*. Cluj Napoca, RO: Risoprint Publishing House.

Palozza, P., Catalano, A., Simone, R., Cittadini, A. (2012). Lycopene as a guardian of redox signalling. *Acta Biochimica Polonica*, 59(1).

Panaite, T. D., Criste, R. D., Saracila, M., Tabuc, C., Turcu, R. P., Olteanu, M. (2018). The use of ascorbic acid and *Artemisia annua* powder in diets for broilers reared under heat stress. *Romanian Biotechnological Letters*, 23(5), 13976-13985.

Pogurschi, E.N., Sârbu, N.D., Nicolae, C.G., Zugravu, C.A, Vlad, I., Maftei, M., Marin, M.P., Munteanu, M.F. (2019). Beneficial uses of chromium in laying hens nutrition: a review. *Scientific Papers. Series D. Animal Science*, LXII (2), 65-70.

Rostagno, M.H. (2009). Can stress in farm animals increase food safety risk? *Foodborne Pathog*., 6, 767–776.

Sahin, K., Sahin, N., Onderci, M., Yaralioglu, S., Kucuk, O. (2001). Protective role of supplemental vitamin E on lipid peroxidation, vitamins E, A and some mineral concentrations of broilers reared under heat stress. *Veterinarni Medicina-Praha*, 46(5), 140-144.

Sahin, N., Sahin, K., Kucuk, O. (2001). Effects of vitamin E and vitamin A supplementation on performance, thyroid status, and serum concentrations of some metabolites and minerals in broilers reared under heat stress(32oC). *Veterinarni Medicina-Praha*, 46 (11/12), 286-292.

Sahin, K., Sahin, N., Onderci, M., Gursu, F., Cikim, G. (2002). Optimal dietary concentration of chromium for alleviating the effect of heat stress on growth, carcass qualities, and some serum metabolites of broiler chickens. *Biological Trace Element Research*, 89(1), 53-64.

Sahin, K., Sahin, N., Kucuk, O., Hayirli, A., Prasad, A. (2009). Role of dietary zinc in heat-stressed poultry: A review. *Poultry Science*, 88(10), 2176-2183.

Sahin, K., Orhan, C., Akdemir, F., Tuzcu, M., Iben, C., Sahin, N. (2012). Resveratrol protects quail hepatocytes against heat stress: modulation of the Nrf2 transcription factor and heat shock proteins. *Journal of animal physiology and animal nutrition*, 96(1), 66-74.

Sahin, K., Orhan, C., Tuzcu, M., Sahin, N., Hayirli, A., Bilgili, S., Kucuk, O. (2016) Lycopene activates antioxidant enzymes and nuclear transcription factor systems in heat-stressed broilers. *Poultry Science*, 95, 1088-1095.

Selye, H. (1976). Forty years of stress research: principal remaining problems and misconceptions. *Canadian Medical Association Journal*, 115(1), 53.

Sohail, M. U., Ijaz, A., Yousaf, M. S., Ashraf, K., Zaneb, H., Aleem, M., Rehman, H. (2010). Alleviation of cyclic heat stress in broilers by dietary supplementation of mannan-oligosaccharide and Lactobacillus-based probiotic: Dynamics of cortisol, thyroid hormones, cholesterol, C-reactive protein, and humoral immunity. *Poultry science*, 89(9), 1934-1938.

Trifunschi, S., Munteanu, M, Pogurschi, E., Gligor, R. (2017). Characterisation of polyphenolic compounds in *Viscum album* L. and *Allium sativus* L. extracts. *Revista de Chimie*, 68, 1677-1680.

Tůmová, E., Gous, R. M. (2012). Interaction of hen production type, age, and temperature on laying pattern and egg quality. *Poultry Science*, 91(5), 1269-1275.

Turcu, R. P., Tabuc, C., Vlaicu, P. A., Panaite, T. D., Buleandra, M., Saracila, M. (2018). Effect of the dietary oregano (*Origanum vulgare* L.) powder and oil on the balance of the intestinal microflora of broilers reared under heat stress (32°C). *Scientific Papers. Series D, Animal Science,* LXI (1), 77-86.

Wu, X. Z., Wen, Z. G., Hua, J. L. (2019). Effects of dietary inclusion of Lactobacillus and inulin on growth performance, gut microbiota, nutrient utilization, and immune parameters in broilers. *Poultry science*, 98(10), 4656-4663.

Yardibi, H., HOŞTÜRK, G. T. (2008). The effects of vitamin E on the antioxidant system, egg production, and egg quality in heat stressed laying hens. *Turkish Journal of Veterinary and Animal Sciences*, 32(5), 319-325.