

# Vitamin E and Fertility in the Poultry Birds; Deficiency of Vitamin E and its Hazardous Effects

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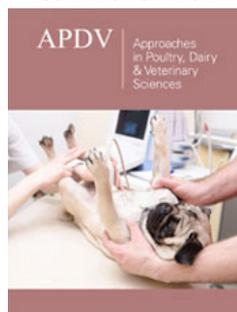
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## Abstract

Vitamin E plays a significant role in growth, tissue integrity, reproduction, nervous system and disease resistance. Fertility plays a vital role in human, animals and avian species. But, several factors such as climatic variation, diet, minerals, and vitamins can affect fertility. Vitamin E acts as an antioxidant and increases disease resistance against infectious agents in animals which, in response, increases fertility in animals and poultry birds. Vitamin E performs an excellent role in birds including egg production, egg fertility, hatchability, sperm motility, conception rate, and postnatal growth. Its main function is to inhibit the production of reactive oxygen species (ROS) in the cells and tissues. In addition, Vitamin E provides biological stability to spermatozoal plasma membranes in male birds and maintains the egg quality in female birds by preventing the generation of ROS. Numerous studies have described that vitamin E deficiency reduced fertility in humans and avian species. However, very little data is available on vitamin E supplementation and its deficiency on the fertility of poultry birds. Therefore, this paper aims to explore the effects of the supplementation of vitamin E on the fertility of poultry birds in order to understand the beneficial role of vitamin E in the maintenance of sperm and egg qualities. This review may provide important scientific information to better understand the mechanism of vitamin E and its possible effects on fertility functions in the poultry species.

**Keywords:** Vitamin E; Poultry; Oxidative stress; Fertility; Antioxidant

## Introduction

Nutrition plays a significant role in reproductive efficiency of human and animals. Vitamin E has been involved in muscular activity, tissue integrity, reproductive function, immune response and nervous systems [1]. Various literature findings have investigated that vitamin E appears in biosynthesis of DNA, skeletal muscles development, oxidation-reduction reactions and cellular respiration of heart [2]. Vitamin E acts as an important element to maintain brain structure. Thirteen vitamins named alphabetically vitamin A-vitamin K have been discovered. In the early 1920s, Evans and Bishop discovered fat-soluble vitamin E [3]. Various reports have exposed the nutritional consequence of vitamin E in humans, lab animals, and avian species. Vitamin E has interaction with some other dietary components, including selenium, sulfur-containing amino acids, polyunsaturated fatty acids and synthetic antioxidants [4,5].

Vitamin E possesses many biological characteristics such as the ability of antioxidant, immunostimulation and improvement of detoxification [4-6]. Vitamin E activates specific and nonspecific immune responses toward infectious diseases [7,8]. Vitamin E has a vital role in egg production, egg fertility, hatchability, and sperm motility. But Vitamin E deficiency has several disadvantages including crazy chick disease, muscular weakness, enlarged hocks, the disorder in nervous system, circulatory system, muscular system, skeletal system, immune system, and reproductive system [8-10]. Vitamin E deficiency can increase the incidence of infection, heart disease and breast cancer [9,10]. The above-mentioned adverse effects of vitamin E deficiency produce major economic losses in the poultry industry. Numerous published animal studies have reported that vitamin E has low toxicity, but it still has not been categorized as carcinogenic, mutagenic and/or teratogenic [10].

Vitamin E is very important for humans and poultry species. Reproductive health is a crucial issue for healthy offspring in all animals [11]. Reactive oxygen species are produced as a result

of lipid peroxidation and affect the fertility of poultry birds. Vitamin E deficiency causes abnormal spermatogenesis and failure to retain fetal resorption in males and females birds respectively [7,9]. There is lack of sufficient data on the role vitamin E supplementation in the poultry birds and its possible hazardous consequences. Therefore, the present study aim was to estimate the effects of the supplementation of vitamin E in the poultry species; deficiency of vitamin E and its possible hazardous effects.

### Vitamin E in Poultry Nutrition; Why it is Important?

Vitamin E has powerful antioxidant property and plays significant role in nervous system [12]. Its deficiency in chicks causes three main disorders

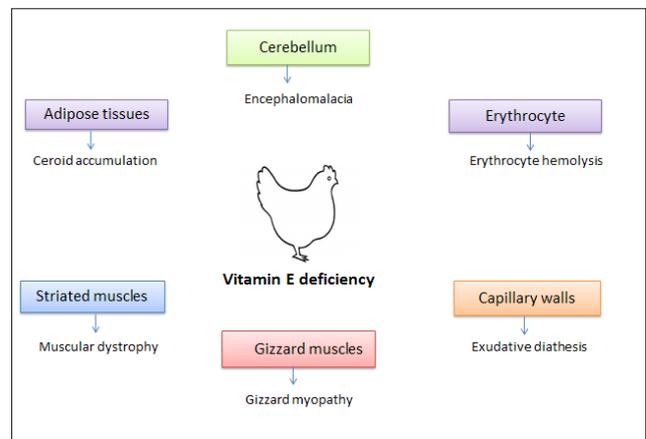
1. Encephalomalacia (crazy chick disease),
2. Exudative diathesis, and
3. Muscular dystrophy.

Various environmental and dietary factors affect the poultry health. But the above mentioned three disorders produce economic losses in the poultry industry. Mostly, vitamin E deficient diet given to commercial flocks causes encephalomalacia. There are several reasons behind this disorder due to less amount of antioxidant in feed and/or high concentration of an unsaturated and unstable fat. Vitamin E and selenium deficient diet have critical role in exudative diathesis. While diet deficient in vitamin E and sulfur amino acids cause muscular dystrophy in chicks because chicks tissues needs sulfur amino acids for proper growth. Therefore, there is need to investigate the optimum levels of vitamins E in the avian nutrition [13].

### Requirements of Vitamin E for Poultry Birds

Vitamin E is basic requirement for birds growth, tissue integrity, reproduction, nervous system and disease resistance. Furthermore, it increases the nutritional value of eggs and meat. National Research Council (NRC) has provided the nutrients requirements for the avian species. But NRC vitamins requirement data is being used since 20-40 years; and it may cause fertility problem in today's different species of poultry [14]. Therefore, there is need to update vitamins requirements in poultry birds. Vitamin E requirements increase under high temperature conditions. Hence, the supplementation of 500mg/kg vitamin E may help to increase the egg production under hot climatic conditions. Another similar study has described that laying hens consumed 250mg/kg vitamin E diet had decreased harmful effects of high environmental temperature. A research in poultry has showed that the addition of vitamin E between 125 to 300mg/kg had minimized the loss of egg production, eggshell density and feed efficiency [15,16]. While broilers given 200mg/kg vitamin E diet had reduced the production of ROS in different tissues under stressed conditions at 3 to 5 weeks of age. Vitamin E should be supplemented at 12IU/kg and 10IU/kg for Japanese quail and ducks respectively, during starting and growing age. The deficiency of Vitamin E causes various disorders in poultry birds including erythrocyte hemolysis, exudative diathesis and muscular

dystrophy (Figure 1).



**Figure 1:** Effect of vitamin E deficiency on poultry health.

### Supplementation of Vitamin E and Female Birds Fertility

#### Vitamin E as an important ingredient

Vitamin E acts as a chain breaking antioxidant and prevents oxidation of lipids membranes by neutralizing ROS (reactive oxygen species). ROS damages cell of origin and surrounding cells in which more free radicals are produced in a chain reaction leading to tissue destruction [17]. Lipid membranes contain unsaturated fatty acids is more prone to peroxide formation. The peroxidation reaction in lipids membrane can cause oxidation of proteins membrane [18]. A study has reported that metal ions such as iron increased this reaction. A study in broilers has investigated that chicken fed vitamin E diet at 30-50mg/kg had reduced lipid peroxidation which can be observed by decreased levels of MDA (malondialdehyde) [19]. Therefore, vitamin E is an important ingredient to reduce the generation of ROS at their initial phase.

#### Vitamin E and female reproductive function

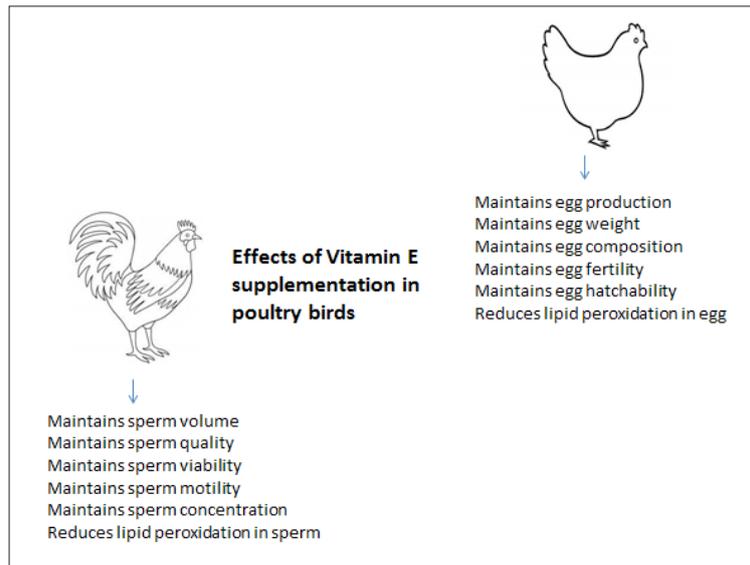
Environmental variation has negative effects on the bird's reproductive and immune defense mechanisms. Stressful conditions disturb various hormones including epinephrine and glucocorticoids [17]. Antioxidant has sufficient capacity to remove ROS but after exposure to heat stress this may cause suppression in antioxidant metabolites. Vitamin E has antioxidant property that may protect tissue from lipid peroxidation which is caused by production of ROS and affect the egg quality in laying hens [20,21]. Numerous studies have investigated the beneficial effects of vitamin E supplementation in laying hens under heat stressed conditions. The above study recommended that vitamin E 250mg fed to laying hens may reduce the harmful effects of high temperature in laying hens [17].

#### Vitamin E requirements for female birds

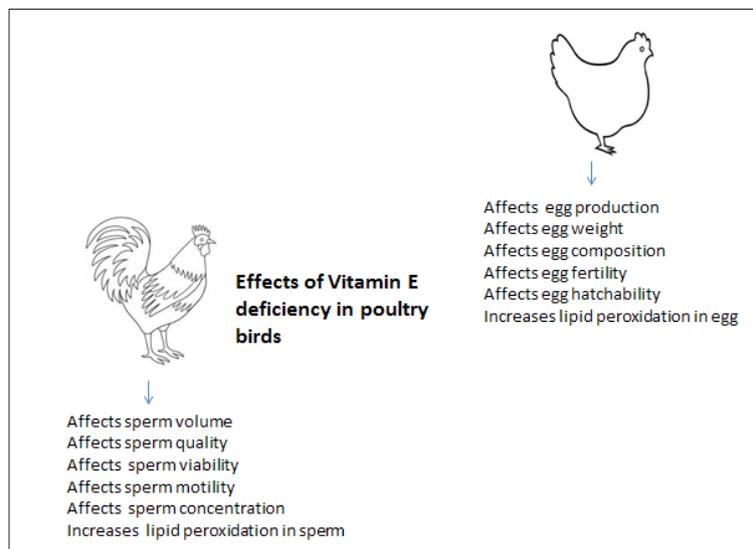
Vitamin E has great significance in poultry birds due to its egg transference property. A study has found that 100g of whole eggs contains almost 3IU of vitamin E concentration. A study has

stated that vitamin E 60IU/kg feed had increased egg production, yolk weight, albumen weight and vitelline membrane strength [22]. However, total egg weight, yolk color, yolk viscosity and emulsification capacity was not enhanced by addition of vitamin E. Laying hens supplemented with vitamin E and vitamin C at 65IU/kg and 1,000ppm respectively improved in vitro lymphocyte proliferative responses under harsh environmental condition [23]. Various authors have determined that high concentration of vitamin E supplementation at 250ppm had improved fertility and production performance. The above authors have suggested that this was considered a defensive management practice to reduce the

adverse effects of increasing environmental temperature in broilers [19]. They concluded that high level of vitamin E reduced MDA metabolite which plays a key role in lipid membrane peroxidation [24]. The supplementation of vitamin E at 125 to 300mg/kg improved feed efficiency rate, egg production and eggshell density [25]. The potential effects of vitamin E supplementation on fertility of poultry birds are described in Figure 2. Therefore, by reviewing scientific literature of vitamin E effects on male and female birds, it has been suggested that birds supplemented with 100mg vitamin E/kg feed may prevent the issue of vitamin E deficiency (Figure 3).



**Figure 2:** The potential effects of vitamin E supplementation on fertility of poultry birds (male and female).



**Figure 3:** The potential effects of vitamin E deficiency on fertility of poultry birds (male and female).

### Supplementation of Vitamin E and Male Birds Fertility

#### Vitamin E as antioxidants

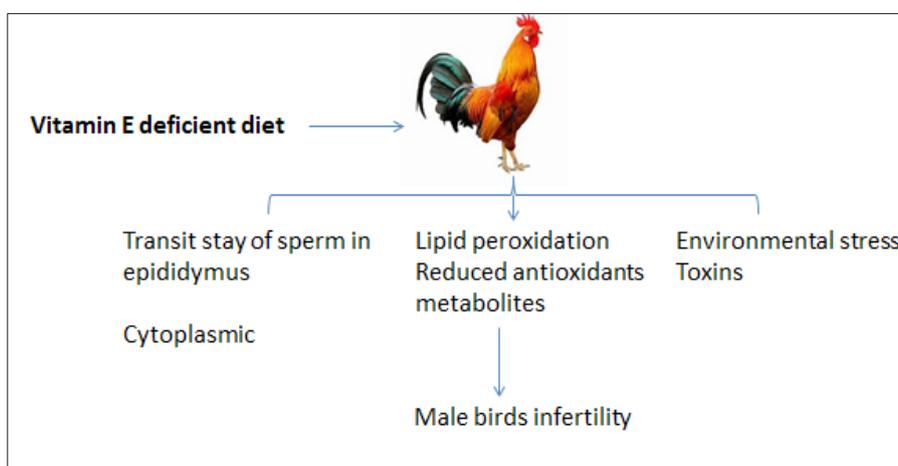
Vitamin E as antioxidant has function to hinder free radicals generated from unsaturated fatty acids under heat stress

conditions [26]. Vitamin E is involved in the intracellular defense mechanism towards the negative effects of ROS that activate the oxidation of unsaturated phospholipids and critical sulphhydryl groups [26]. Particularly, phospholipids membranes are more prone to oxidative stress, being positively correlated with the

degree of poly unsaturation of fatty acids. Vitamin E has been classified as a reducing agent for ROS molecules. This reaction results in the destruction of thousands of poly unsaturation of fatty acids molecules [27]. ROS damages the biological systems for example hydroxyl radical ( $\bullet\text{OH}$ ), superoxide anion radical ( $\text{O}_2^-$ ), singlet oxygen ( $\text{O}_2$ ) and hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) are continuously produced in the process of normal aerobic cellular metabolism [26,27]. However, these oxidative molecules can damage healthy cells if they are not eliminated.

Various environmental factors can affect the sperm and/or semen quality [28,29]. Dietary supplementation of minerals, vitamins, and antioxidants can reduce the above mentioned hazardous effects. The supplementation of an antioxidant feed additive in the poultry feed should be required in order to avoid lipid peroxidation

(Figure 4) [30]. A study has investigated that birds consumed 100mg/kg of vitamin E diet had the higher status of vitamin E in semen and spermatozoa as compared to those birds supplemented with 10mg/kg of vitamin E [31]. These above discussed studies propose that increased antioxidant status of semen was based on the increased quantity of vitamin E in the bird's diet. Vitamin E acts as a chain-breaking antioxidant, thus; it neutralizes free radicals and inhibits the oxidation of lipids membranes [10]. Consequently, there is need to add vitamin E in poultry diet to increase antioxidant metabolites in semen and/or spermatozoa which is essential for the prevention of male infertility. Poultry given antioxidant diet maintain the structural integrity of cells by stabilizing highly reactive free radicals [10]. Therefore, the main role of vitamin E is to overwhelm the production of ROS at their initial phase and maintain immune system of chickens.



**Figure 4:** Mechanism of fertility in poultry birds.

### Vitamin E and immune system

Several diseases (infectious and non-infectious) are threat in poultry industry which cause major economic losses. Vitamin E stimulates immune responses by hindering the production of ROS in lipid membranes [32-34]. Various reports has explored that vitamin E plays vital role in the immune function. Therefore, it is necessary to enhance the immune response and disease resistance in the poultry birds by application of nutrients modification which can be best practical and efficient strategies for improving production performance in poultry farming [35]. NRC (National Research Council) recommends vitamin E 5-25IU/kg of feed to improve the immune response but if poultry farmers use vitamin E levels as high level as 25 times up to NRC requirement have increased antibody titer in turkeys [35]. Furthermore, it has been observed that nutrient requirement for growth rate are different when compared with immune response and disease resistance [35].

### Deficiency of vitamin E and male birds' reproductive system

Vitamin E helps in improving the quality and motility of the sperm due to its antioxidant property. Vitamin E decreases the DNA defects of sperm via reducing the production of free radicals.

The DNA defects of the sperm cause birth defects. Several studies have explored that male birds supplemented with increased quantity of vitamin E had improved sperm quality and/or motility when compared with control group [21,27]. The results showed that the semen volume, sperm motility, and sperm capacity in fertilizing eggs were increased in vitamin E supplemented group as compared to control group. The above studies stated that vitamin E supplementation protects semen quality by preventing the breakdown of polyunsaturated fatty acids. The recommended concentration of vitamin E for maintaining male fertility in poultry diet can be different depending on age, breed, health status and concentration and composition of vitamin E. Various authors have recommended that a poultry feed should be supplemented with 10mg vitamin E/kg of feed to maintain the fertility in avian species [32,36-38].

### Conclusion and Recommendation

Fertility plays a significant role in human, animals and birds. But, many factors such as environment, diet, minerals, and vitamins can affect fertility. Vitamin E increases fertility in human and animals including poultry species. Moreover, vitamin E increases disease resistance in farm animals against infection. Therefore, vitamin E is key feed ingredient which acts as an antioxidant and plays an important role in growth, tissue integrity, reproduction system,

nervous system and disease resistance. Vitamin E is essential for egg production, egg fertility, and hatchability, sperm motility, transport of sperm, conception rate as well as postnatal growth. Thus, this paper aim was to evaluate the effects of vitamin E on fertility of the poultry birds and its possible consequences associated with vitamin E deficiency. Furthermore, vitamin E deficient diet impairs fertility in the poultry birds (male and female). Therefore, we suggest that moderate level of vitamin E (75-100mg/kg) should be supplemented in the poultry diet to avoid the adverse effects.

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