EJONS
Uluslararası Matematik, Mühendislik ve Doğa Bilimleri Dergisi
International Journal on Mathematic, Engineering and Natural Sciences

Review Article e-ISSN: 2602 - 4136 https://doi.org/10.5281/zenodo.15106952

Vitamın C in Animals of Economic Value

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Article Info

Received: 03.02.2025
Accepted: 21.02.2025

Keywords
Antioxidant
Vitamin C
Rosehip
Ruminant

Abstract: Vitamin C (VC) is water-soluble and synthesized from glucose. D-glucose → d-glucuronic acid → l-gulonic acid → l-gulono-γ-lactone → l-VC. This event occurs in the liver in mammals ruminants and in the kidney in reptiles. The endogenous synthetic capacity of VC decreases in exposure to stress. Ruminants are more sensitive to VC deficiency because VC administered orally is rapidly destroyed by the rumen microflora and alkaline pH. Synthesis begins with glucose in the liver and occurs in the mitochondria via uronic acid. VC is one of the most important antioxidants in extracellular fluids. It also has antioxidant activity inside the cell. Hypochlorite binds and neutralizes peroxide and hydroxy radicals, hydrogen peroxide, superoxide anion and singlet oxygen. Water-soluble vitamins (VCs) must be taken regularly to prevent hypovitaminosis due to their low storage. VC accelerates chemotaxis, promotes the growth and proliferation of lymphocytes, and helps kill bacteria by leukocytes. It also has bacteriostatic activity. The presence of VC significantly inhibits bacterial replication. Additionally, VC prevents lipopolysaccharide-mediated lung injury in sepsis. It also promotes apoptosis and supports immunity by protecting endothelial progenitor cells. It is found in significant amounts in tomatoes, citrus fruits, green leafy vegetables, fruits and milk. It is significantly denatured during pasteurization of milk. Orange and lemon juice contains approximately 0.5 mg VC per ml. In this study, the effect of VC, especially on animals with economic value, was investigated.

1. Introduction

Vitamin C (VC) is water-soluble and synthesized from glucose (Travica et al., 2017). This synthesis (d-glucose → d-glucuronic acid → l-gulonic acid → l-gulono-γ-lactone → l-VC) occurs via uric acid in the mitochondria of the ruminant liver. This process is carried out in the kidneys, again from d-glucose, in reptiles and chickens. The gene responsible for the formation of the enzyme L-gulono-γ-lactone oxidase, which plays a role in the final stage of VC biosynthesis in humans, primates, guinea pigs, bats, fish, birds and insects, has lost its activity (İmik and Tuncer, 1997; Konca and Yazgan, 2002; Kaplan and Gönül, 2010). In case of exposure to stress (such as dehydration, infectious and cardiovascular diseases, cancer, diabetes and sepsis), the endogenous capacity of VC decreases. The consequences of this situation are susceptibility to infections, reduced productivity and increased mortality (Akinmoladun, 2021; Başeğmez and Eryavuz, 2021). VC taken orally in ruminants is rapidly destroyed by the alkaline pH and microflora of the rumen. For this reason, ruminants are more sensitive to VC deficiencies and are administered parenterally (dose 1-2 grams). Synthesis occurs in the mitochondria, starting from glucose in the liver and via uronic acid (İmik and Tuncer, 1997; Doğan, 2023). Calves cannot synthesize VC until they are two years old. Three

week old calves receive this with milk and colostrum. In newborn calves, frozen and fresh colostrum are sufficient sources of VC (Ranjan, 2012). The VC concentration in cow and goat milk is approximately 1-2 mg/100 mL (Renner, 1983).

VC is a co-factor that contributes to the glucocorticoid biosynthesis pathway by participating in steroid hormone synthesis. It also neutralizes hypochlorite, hydrogen peroxide, hydroxyl radicals, superoxide anion and singlet oxygen (Patak et al., 2004; Aktaş and Armağan, 2019; Aktas and Bayram, 2020; Aktaş and Sevimli, 2020; Aktas and Ozgocmen, 2020; Aktas and Gur, 2021; Aktaş and Yahyazadeh, 2022).

The immune system protects the body from pathogens such as viruses, bacteria, parasites and fungi. It is also a network of tissues, special organs, proteins, cells and chemicals. Due to its low storage capacity, adequate and regular intake is necessary to prevent hypovitaminosis (Carr and Maggini, 2017). VC improves chemotaxis in disease states, promotes lymphocytic proliferation, and helps kill bacteria by leukocytes. It also has bacteriostatic activity. The presence of VC significantly inhibits bacterial replication. In addition, VC reduces lipopolysaccharide-mediated lung injury during sepsis. In addition, it inhibits apoptosis. In its deficiency, the killing of bacteria by natural killer cells is delayed (Teng et al., 2018).

It is found in cabbage, pepper, potato, strawberry, tomato, citrus fruits, green leafy vegetables, fruits and milk in significant amounts. It is significantly denatured during pasteurization of milk. Orange and lemon juice contains approximately 0.5 mg VC per ml (Dizlek and Gül, 2007; Kaya et al., 2013).

In this study; the importance of VC in terms of health, which diseases it is good for and which fruits and vegetables it is found in large amounts were examined.

2. Diseases

2.1. Immune system and infection

There is approximately 100 times more VC in immune system cells than in serum. VC is directly effective in destroying pathogens. It is virucidal and bactericidal, especially in the presence of metal ions. It creates this effect by disrupting the structure of RNA and DNA. VC increases the production of interferons in infected cells and the functions of neutrophils (İmik and Tuncer, 1997).

VC also prevents free radical-induced damage and plays a cellular and subcellular protective role. (Englard and Seifter, 1986). The body's VC concentration decreases rapidly during infection and stress. With VC supplementation, the immune system is activated and resistance to infections develops (Ran et al., 2018). VC improves chemotaxis, supports lymphocytic proliferation and helps kill bacteria by leukocytes in bacterial infections. It also shows bacteriostatic activity by inhibiting bacterial replication (Teng et al., 2018). VC plays an important role in wound repair as it stimulates collagen production (Naidu, 2003). VC prevents neonatal calf diarrhea (Sivakumar et al., 2010).

2.2. Mastitis

Mastitis includes physical, chemical and bacteriological (contaminant; S. bovis, S. aureus, S. agalactia and environmental; E. chromogenes, P. uberis, S. aeruginosa, S. coli and other coagulase negative staphylococci) changes in milk, as well as pathological changes in the mammary glandular tissue. In clinical mastitis, significant inflammatory symptoms are observed in the milk and breast tissue. In subclinical mastitis, no visible changes occur. 75% of milk somatic cells are leukocytes (lymphocytes, neutrophils and macrophages) and 25% are epithelial cells. The number of leukocytes and epithelial cells in milk increases in breast infections. While the number of healthy breast somatic cells is considered to be less than

100,000 cells/ml, when an intramammary infection develops, the number of leukocytes (neutrophils) increases significantly in parallel with the increased immune response to the infection. This number is 150,000-500,000 in those with suspected California Mastitis Test (CMT), 400,000-1,500,000 in those with CMT (+), 800,000-5,000,000 in those with CMT (++) and more than 5,000,000 in those with CMT (+++). The mechanism of this event is the increase in leukocytes during inflammation (Albenzio et al., 2002; Peker et al., 2016). In this table, VC per unit cell and milk serum VC levels decrease. This need is met by increasing the uptake of VC into the cell from the milk serum (Baştan, 2014).

2.3. Reproductive system diseases

The testicles are sensitive to a decrease in the level of VC in the body. VC protects sperm DNA from oxidative damage. It plays an important role in preserving the genetic integrity of sperm as it protects sperm from the destructive effects of ROS. In men, increasing dietary VC intake increased sperm vitality, motility, and total mature sperm count. It also reduced sperm adhesion and abnormality percentage (Eidan, 2016). VC application increased embryo survival and quality. This is due to increased progesterone production in the early stages of pregnancy, maturation of the placenta, improvement of the function of the uterus and fallopian tubes, improvement of blastocyst development, and prevention of fetal resorption (Hashem et al., 2015). Stress is the body's response to an external effect. The stress center is the hypothalamus. It produces corticotropin (CRF) depending on the stimulus. It causes the secretion of adrenocorticotropin (ACTH) hormone from the pituitary gland. ACTH directly affects the adrenal cortex for the production and secretion of corticosterone, which is called the stress hormone. Corticosterones shift body reserves (protein, carbohydrate and fat) and productivity functions (such as development, egg production, immune system and fertility) to the current stressor situation. In this case, it causes an increase in heat loss, acceleration in respiration, heart rate and blood circulation (İmik and Tuncer, 1997).

VC is naturally found in various foods. Under normal conditions, laying hens can produce VC. However, in cases of high heat stress, the level of VC produced decreases and body stores are rapidly depleted. VC increases the resistance of birds to heat stress by regulating the release of corticosteroid hormones during heat stress (Seeman, 1991). VC also plays an important role in vitamin D, calcium metabolism and the formation of collagen fibrils necessary for egg shell formation. In VC deficiency, egg shells with low texture occur (Bains, 1997).

3. Foods Containing Vitamin C

The VC potential in citrus fruits is not very high. VC is found especially in the fleshy part of the orange. Rosehip is a very rich source of VC. Although milk contains a very high amount of VC, the pasteurization process breaks down a large portion of this vitamin. The concentration in full-fat goat and cow milk is approximately 1-2 mg/100 Ml. The plasma concentration of VC in cattle, sheep and goats is shown as (mg/L) (Table 1) (Renner, 1983; İmik and Tuncer, 1997).

Table 1. VC concentration in plasma of goats, sheep and cattle (mg/L)

Species	Concentration (range)
Goat	1.75-1.92
Sheep	4-8
Cattle	5.7-6.2

It is also found in green leafy vegetables (lettuce, spinach and parsley), tomatoes, green peppers, cabbage, broccoli, strawberries, grapes, melons, blackberries, bananas, watermelons and fresh potatoes. Packaged orange juices sold in the market under the names of nectar and similar names contain less VC since they are diluted. The acidity of the environment increases

the stability of VC. Staling, exposure to heat and chopping of plant foods containing VC cause the vitamin content to decrease. Copper and other metals that can pass into cooking water in trace amounts from metal containers also facilitate the separation of VC into pieces. Properly canned vegetables can preserve a large portion of the VC in them (Akıcı et al., 2012).

4. Discussion

VC added to the feed in stress conditions caused by extreme heat and cold not only reduces the level of corticosteroids in the adrenal glands but also is effective in reducing the mortality rate. While the mortality rate in young roosters left in extreme heat was 22%, this rate decreased to 7.3% in those receiving VC. VC restricts cell disintegration due to its antioxidant properties. VC also prevents potassium loss in diarrhea caused by increased heat (Roche, 1992). Gurer et al. (1990) reported that while the mortality rate was 0.09% in groups supplemented with 1500 ppm VC in broiler diets, this rate increased to 0.21% in the control group. VC added to laying hen diets in order to reduce the negative effects of heat stress has been found to improve performance and shell quality. These results vary depending on the animal material and the environmental temperature. In addition, the doses applied and the results obtained are very variable because the various forms of VC (crystalline or coated form) are easily damaged by exposure to heat, humidity and direct sunlight (Tilman, 1993). Therefore, the results obtained by adding VC to the diets of heat-stressed animals should be checked. A decision should be made to add VC to the diets according to these results (Konca and Yazgan, 2002). Parenteral VC administered to newborn calves increases resistance to bacterial and viral infections. VC given at a daily dose of 2 g reduced deaths due to enteritis and pneumonia (Serpek et al., 1989). Doğan (2023), increased the level of serum IgG and the number of lymphocytes in 5 mg/kg VC administered together with the vaccine against blackleg disease in cattle, thus increasing the protective effect of immunity. In a study conducted on rats by Artıran et al. (2017), testicular damage caused by gentamicin administration (intense damage and cellular shedding in spermatogenic cells, thickening of the basal lamina, intense damage and atrophy in tubules, expansion in the interstitial area and congestion in vessels) was minimized with VC administration and approached the control group. In another study, intramuscular (i.m.) administration of 50 mg VC increased the pregnancy rate in Red Sokoto goats (Omontese et al., 2014). It has been reported that VC (20 mg/kg; i.m) application for 30 days in rams increased sperm concentration, volume and motility (Sönmez and Demirci, 2003). In high-yielding cows that did not become pregnant despite insemination, subcutaneous (sc) administration of 2 g VC per 500 kg body weight one week before insemination increased the pregnancy rate (Başpınar, 1988). There is a positive relationship between semen VC level and sperm motility in animals. In bulls with libido deficiency, libido was observed to be normalized with sc administration of VC (Gadient and Wegger, 1984). İmik and Tuncer (1997), in their study, high sperm motility (R:0.77) was found in Holstein-Friesian and Zebu bulls with 500 kg live weight and no sexual activity, and 2 g VC was applied twice a week for 4-6 weeks, showing a low sperm count (R:0.55 and R:0.60). Mastitis is an important problem in dairy cattle farming. It suppresses milk production in the affected udder lobe and causes serious economic losses. Peker Akalın et al. (2016), in his study, observed that as the degree of subclinical mastitis increases, the number of somatic cells increases, the milk serum VC level decreases, and the VC level per unit cell decreases. In another study by Weiss et al. (2004), a significant decrease in VC levels was observed in Escherichia coli-induced mastitis. In the study by Ranjan et al. (2012), it was observed that parenteral administration of VC alone or together with intramammary antibiotics increased the recovery rate in spontaneous cases of bovine mastitis.

5. Conclusion

VC is a powerful antioxidant. It is found in blood plasma, neutrophils and other body tissues. It has physiological functions at cellular and subcellular levels in the regulation of immunity and in many cases in the protection against oxidative damage. Although cattle can

synthesize VC from D-glucose or D-galactose, a decrease in VC density is observed in tissues in cases of disease and stress. However, comprehensive studies are needed to investigate the necessity and effect of VC supplementation in cattle. Reduction of heat stress, calf diarrhea, mastitis and infertility are some of these adverse conditions. Which VC supplements can be beneficial? Development and dose standardization of stable VC supplements in the rumen, their preventive and therapeutic effects should be investigated.

References

Akıcı, A., Akova, M., Duman, D.K., Erdemli, İ., Babaoğlu, M.Ö., Birincioğlu, M., Bozkurt, A., Dalkara, T., Yıldırım, İ.A., 2012. C vitamini. In O. Kayaalp (Ed.), Akılcı Tedavi Yönünden Tıbbi Farmakoloji.

Akinmoladun, O.F., 2021. Stress amelioration potential of vitamin C in ruminants: a review. *Tropical Animal Health and Production,* 54(1): 24.

Aktaş İ., Armağan, İ., 2019. Investigation of the positive effects of silymarin on valproic acid-induced 5. liver damage in rats. A*dıyaman Üniversitesi Sağlık Bilim Derg*isi, 5(2): 1445-1458.

Aktas, I., Bayram, D., 2020. Investigation of the effects of silymarin on valproic acid-induced kidney damage in rats. *Harran Üniversitesi Veteriner Fakültesi Dergisi*, 9(1): 42-48.

Aktas, I., Gur, F.M., 2021. The effects of thymoquinone and β-aminoisobutyric acid on brain tissue of streptozotocin-induced diabetic rats. *International Journal of Veterinary and Animal Research*, 4: 1–6.

Aktaş, İ., Yahyazadeh, A., 2022. Protective potential of misoprostol against kidney alteration via alleviating oxidative stress in rat following exposure to paclitaxel. *Tissue and Cell*, 79: 101966.

Aktaş, İ., Gür, F.M., Özgöçmen, M., 2020. Silymarin ameliorates valproic acid-ınduced pancreas ınjury by decreasing oxidative stress. *International Journal of Veterinary and Animal Research*, 3(2): 34-38.

Aktas, I., Ozgocmen, M., 2020. The treatment effect of silymarin on heart damage in rats. *Annals of Medical Research*, 27(3): 948.

Aktaş, İ., Sevimli, M., 2020. Protective effects of silymarin on brain ınjury in rats. *Van Veterinary Journal*, 31(2): 87-92.

Albenzio, M., Taibi, L., Muscio, A., Sevi, A., 2002. Prevalence and etiology of subclinical mastitis in intensively anaged flocs and related changes in the yield and quality of ewe milk. *Small Rum Res*earch, 43: 219-226.

Artıran, M., Burukoğlu, D., Bayçu, C., Yılmaz, H., 2017. Gentamisin'le testis hasarı oluşturulan sıçanlarda c vitamininin koruyucu etkisi protective effect of vitamin c from gentamicin ınduced testicular damage in rats. *Osmangazi Tıp Dergisi*, 39(2): 32-9.

Bains, B.S., 1997. Ascorbic acid influence on egg shell, fertility and hatchability. *World Poultry Misset*, 13(1): 97.

Başeğmez, M., Eryavuz, A., 2021. Sıçanlarda oral yüksek doz vitamin c takviyesinin serum vitamin c, leptin ve kortizol parametrelerine etkisi. *Kocatepe Veterinary Journal*, 14(3): 339-345.

Başpınar, N., 1988. Askorbik asit ve metabolizması. Doktora Semineri, Selçuk Üniversitesi Sağlık Bilimleri Enstitüsü, Konya.

Baştan, A., 2010. İneklerde meme sağlığı ve sorunları. Kardelen Ofset Matbaacılık, Ankara.

Carr, A., Maggini, S., 2017. Vitamin C and ımmune function. *Nutrients*, 9(11): 1211.

Dizlek, H., Gül, H., 2007. L-Askorbik asit ve ekmekçilikteki işlevleri. *Ziraat Fakültesi Dergisi*, 2(1): 26-34.

Doğan, E., 2023. Effect of vitamin c on the ımmune system in cattle ımmunized with blackleg vaccine. V*eterinary Journal of Mehmet Akif Ersoy University*, 8(2): 83-88

Englard, S., Seifter, S., 1986. The biochemical functions of ascorbic acid. *Annual Review of Nutrition*, 6: 365–406.

Eidan, S.M., 2016. Efect on post-cryopreserved semen characteristics of Holstein bulls of adding combinations of vitamin C and either catalase or reduced glutathione to Tris extender. *Animal Repro- duction Science*, 167: 1–7.

Gadient, M., Wegger, İ., 1984. Ascorbic acid in ıntensive animal husbandry annual report of the sterility. *Research Institute, Royal Veterinary and Agricultural Universitiy, Copenhagen*, 27: 1-44.

Gürer, C., Özdemir, S., Erbaş, İ., 1990. Effect of vitamin c supplementation on transport mortality, live weight and carcass yield of broilers. *Ankara Üniversitesi Veteriner Fakültesi* Dergisi, 37(2): 459-6.

Hashem, N.M., El-Azrak, K.M., Nour El-Din, A.N.M., Taha, T.A., Salem, M.H., 2015. Efect of GnRH treatment on ovarian activity and reproductive performance fow-prolifc Rahmani ewes. *Theri Ogenology*, 83: 192–198.

İmik, H., Tuncer, Ş.D., 1997. Effects of ascorbic acid on animal nutrition. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 37(1): 109-129.

Kaplan, B., Gönül, B., 2010. C vitamini uygulamalı kısıtlı gıda alınımının bazı dokuların c vitamini düzeylerine etkisi. *Maltepe Tıp Dergisi*, 2(2): 26-31.

Kaya, S., Pirinçci, İ., Ünsal, A., Traş, B., Bilgili, A., Akar, F., 2013. Vitaminler. In S. Kaya (Ed.), Veteriner Farmakoloji (5th ed.,). Medisan Yayınevi.

Konca, Y., Yazgan, O., 2002. Yumurta Tavuklarında sıcaklık stresi ve vitamin c. *Hayvansal Üretim*, 43(2): 1-7.

Naidu, K.A., 2003. Vitamin C in human health and disease is still a mystery? An overview. *Nutrition Journal*, 2(7): 1-10.

Omontese, B.O., Rekwot, P.I., Ate, I.U., Rwuaan J.S., 2014. Ascorbic acid enhances conception rates of Red Sokoto goats following proges- tin (FGA-30 ®, FGA-45® and CIDR®) treatment during rainy season. *Livestock Research for Rural Development*, 26: 130.

Onganer, E., Zakiroğlu, K., Çebi, M.M., Arya Doğan, G.Ü., 2020. C Vitamini. Acıbadem Web ve Yayın Kurulu. (https://www.acibadem.com.tr/ilgi-alani/e-vitamini/#genel-tanitim), (Access Date: 01.02.2025).

Patak, P., Willenberg, H.S., Bornstein, S.R., 2004. Vitamin C is an important cofactor for both adrenal cortex and adrenal medulla. *Endocrine Research*, 30(4): 871-875.

Peker Akalın, P., Ergün, Y., Başpınar, N., Doğruer, G., 2016. Subklinik mastitisli ineklerde süt ve süt hücrelerinde vitamin c düzeyleri. *Etlik Veteriner Mikrobiyoloji Dergisi*, 27(1): 21-26.

Ran, L., Zhao, W., Wang, J., Wang, H., Zhao, Y., Tseng Y., Bu, H., 2018. Extra dose of vitamin

c based on a daily supplementation shortens the common cold: a meta-analysis of 9 randomized controlled trials. *BioMed Research International*, 1837634.

Ranjan, R., Ranjan, A., Dhaliwal, G.S., Patra, R.C., 2012. L-Ascorbic acid (vitamin C) supplementation to optimize health and reproduction in cattle. *Veterinary Quarterly*, 32(3-4): 145-150.

Renner, E., 1983. Milk and dairy products in human nutrition. Munich, Germany: WG Mott. University of Glessen.

Roche, 1992. Vitamin C asitesin şiddetini azaltmaktadır. *Damla*, 1992:3.

Seeman, M., 1991. Is vitamin C essential in poultry nutrition. *Misset World Poultry*. 7(8): 17-19.

Serpek, B., Aslan, V., Tuncer, Ş.D., Ateş, M., 1989. İshalli buzağılarda serum vitamin c ve seruloplazmin düzeyleri ile vitaminin tedaviye etkisi. *Lalahan Hayvancılık Araştırma Enstitüsü* Dergisi, 29(1-4): 35-52.

Sivakumar, A.V.N., Singh, G., Varshney, V.P., 2010. Antioxidants supple- mentation on acid base balance during heat stress in goats. *Asian Australasian Journal of Animal Science*, 23(11): 1462-1468.

Sonmez, M., Demirci, E., 2003. The efect of intramuscular vitamin C administration on semen quality in rams. *Journal of Firat University, Health and Veterinary Science*, 17: 195-201.

Teng, J., Pourmand, A., Mazer-Amirshahi, M., 2018. Vitamin C: The next step in sepsis management? *Journal of Critical Care*, 43: 230–234.

Tilman, P.B., 1993. Vitamin C for laying hens: A rewiev. *Multi-state Poultry Feeding and Nutrition Conference*, Indianapolis, pp. 1-31.

Travica, N., Ried, K., Sali, A., Scholey, A., Hudson, I., Pipingas, A., 2017. Vitamin c status and cognitive function: A systematic review. *Nutrients*, 9(9): 1–21.

Weiss, W.P., Hogan, J.S., Smith, K.L., 2004. Changes in vitamin C concentrations in plasma and milk from dairy cows after an intramammary infusion of *Escherichia coli*. *Journal of Dairy* Science, 87: 32–37.