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Popular Article

Role of Vitamin A in Vision, Fertility and Immunity of Ruminant

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Introduction

Vitamin A is necessary for animals because it supports many body processes. The major functions of vitamin A are crucial for maintaining the health and the productivity of cattle, sheep, goats and other ruminants. Vitamin A exists in several forms like retinol which is the primary form, retinyl esters which is the storage form of retinol and retinoic acid, retinaldehyde are the activated form of vitamin A. With recent studies, retinol has become recognized for its anti-ageing property and also helps in development of muscles, forming pre-adipocytes and reducing reactions to allergens in milk proteins. Vitamin A in preformed form comes only from feeds made from animal sources.

Several poly isoprenoid plant pigments called carotenoids can transform into retinoids which gives them vitamin A activity. In animals, enzymatic changes can only change a little bit of the carotenoids into retinol or retinoic acid precursors. Whether they are fully used or not it depends among other things like, how protein is bound, the kind of animal, its diet and vitamin A levels. Usually, ruminant diets are mainly based on roughages and grain cereals and these lack vitamin A. Because herbivores cannot make enough retinol, it is usual to give them extra vitamin A in the form of retinyl acetate. It is well understood that providing enough of this vitamin, whatever the method used, is important. The amount of vitamin A needed depends on environmental conditions, genes and the food being eaten. Gaining a full knowledge of how vitamin A is metabolized in ruminants helps to determine nutrition needs and point out possible health risks comes from not getting enough of the vitamin and offering smart recommendations for addressing deficiencies strategies.

Metabolism of Vitamin A

Retinol metabolism in ruminants involves various organs and tissues, including the intestine and liver. The process of breaking down vitamin A esters is done in the small intestine by pancreatic

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lipases which produce retinol. Most of the vitamin A in the diet is absorbed in the proximal portion of the small intestine. Retinol enters further processing by being first converted into retinyl esters in the enterocytes and incorporated into chylomicrons. Then these chylomicrons travel through the lymphatic system and bloodstream to deliver Vit A to the liver. After entering the liver, vitamin A may be stored or carried to other cells in the body. Large amounts of retinyl esters are stored in the liver and can be released as needed. Retinol-binding protein (RBP) is mainly responsible for carrying vitamin A to the different part of the body. Inside the cell two sequential oxidation reactions occurs. This reaction is catalyzed by retinol dehydrogenases and retinal dehydrogenases and converts vitamin A into its active form, retinoic acid. It is possible for retinaldehyde to be made from β -carotene, a dietary carotenoid that enters the body by simple diffusion and is broken apart by enzymes called dioxygenases exist in the mucosal cells of the intestine. In order to convert retinaldehyde into retinoic acid, it first goes through an addition of a carboxyl group, which retinaldehyde dehydrogenase catalyses. Inconsistent conversion of β-carotene to vitamin A in cattle is probably because the activity of the 15, 15'-dioxygenase enzyme (Huang *et al*., 2018). Despite the fact that β-carotene is able to help provide vitamin A for ruminants, its effectiveness is lowered by differences in levels and difficulty in converting it, its unstable nature, and several factors connected to various animals.

Role of Vitamin A in Vision

Vitamin A’s most biologically active forms are retinal and retinoic acid. Retinoic acid works with retinoid receptors (RAR and RXR) in most parts of the body to control how genes are expressed. The function of Vitamin A helps to ensure proper cell differentiation, development and immune capabilities. In the eye, retinal is part of the light-absorbing opsins in the retina. Therefore, converting light to the neural response needed for vision is only possible with retinol which also has the ability to change to retinoic acid but not back to retinol. While retinoic acid fulfills much of Vitamin A’s core duties, it cannot handle maintaining vision and some aspects of reproduction.

Vitamin A plays a major role in vision, mainly in the process of adjusting to dark adaptation, which is the eye's ability to manage seeing at lower light levels. The visual pigment found in the retina, called rhodopsin, consists of a protein Opsin and a molecule 11-cis-retinal which is derived from vitamin A (Kono *et al*., 2008). In the presence of bright light, bleaching of rhodopsin occurs and 11-cis-retinal is converted into all-trans-retinal, which leads to decrease in visual sensitivity. However, in the presence of low light, enzymes change all trans-retinal into 11-cis-retinal and this molecule pairs with opsin resulting in regeneration of rhodopsin which allows the eyes to see again (Kono *et al*., 2008). Therefore, a lack of vitamin A can result in problems like dark vision, night blindness, and sometimes complete blindness. Lack of vitamin A in calves may lead to more severe issues since it helps with bone formation. Not having enough nutrients may cause irregular bone formation, especially in the skull, and this can lessen the size of the optic canal. Less blood and nerve supply to the eyes due to the constriction usually results in atrophy of the optic nerve. Besides, when the body lacks vitamin A, cerebrospinal fluid absorption is reduced, putting extra pressure inside the skull. More pressure can injure the optic nerve, which in severe cases brings about papilledema and causes permanent blindness. Besides its involvement in the visual cycle, vitamin A keeps the integrity of epithelial tissues and eye mucous membranes intact. Animals with malaise include signs of dryness, corneal thickening, and ulcers of their corneas. Such eye surface changes raise the risk of getting kerato conjunctivitis (pinkeye), which might damage vision even more. It is also important for the immune system since it supports mucosal immunity and lymphocyte function, keeping the eye safe from secondary infections during stress or disease.

Role of Vitamin A in Fertility

Vitamin A is very much important for keeping the reproductive system healthy in both males and females. In males, lack of vitamin A can lead to lower sperm count and less active sperm. In females, a lack of vitamin A can cause irregular estrus cycle, early pregnancy loss, and birth defects in new borns. In males, a part of the testicles called Leydig cells needs vitamin A (in the form of retinol) to grow properly and make testosterone. In females, retinol helps theca cells to become the kind of cells that produce estrogen, a key hormone for reproduction. Because of this, it's important to make sure ruminant animals (like cows and sheep) get enough vitamin A so they can reproduce well and stay productive.

A study demonstrated that in beef cows during super ovulation, administration of vitamin A (retinol palmitate) had a positive impact on embryo quality. The findings showed that the cows administered with vitamin A had a significantly higher ($P < 0.05$) mean number of high-quality and total transferable embryos than the control group which were fed just corn oil (Lawrence *et al*., 2004). Moreover, the mean number of blastocysts was also higher in the cows administered with vitamin A, suggesting an improvement in embryo development. Vitamin A supplementation during superovulation improves embryo health which means more conception and increased production in cattle. (Lawrence *et al*., 2004).

Usually, the actions of vitamin A in the testis happen through retinoid transport, metabolism, and degradation, as well as the activation of nuclear receptors. As retinoic acid (RA) diffuses with difficulty, its first step is often oxidation of dietary vitamin A (retinol) into retinal in the target organs. Retinol is first held in the liver and later reaches target areas that need the right cellular proteins and enzymes to regulate retinoic acid metabolism (Hogarth and Griswold, 2010). Germinal cells use

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retinol attached to RBP and the receptor STRA6 to absorb it from the membrane. Sertoli cells may also hand over the RA to spermatogonia directly or the serum could be used to deliver the RA directly to spermatogonia. Retinol in the cell first becomes RA, then interacts with receptors called RARγ. There is a surplus of cellular retinoic acid–binding protein (CRABPA) in cell. Upon being activated, the receptor can lead to the transcription of Stra8 as well as other genes needed for meiosis in the germ cells (Hogarth and Griswold, 2010).

Role of Vitamin A in Immunity

Vitamin A boosts the immune system by sustaining the shape and performance of epithelial tissues. Bodily areas such as the respiratory, gastrointestinal, and reproductive tracts have these tissues for the first line of defense against potential infections. Not having enough Vitamin A leads to dry, thicker, and hardened epithelial surfaces that can no longer act as an effective barrier, so the animal becomes more at risk for microbe infections. Lack of Vitamin A in young calves causes harm to the epithelial layer in their body. This can open the way for infections in the stomach and along the breathing passages, which leads to slow growth and high morbidity rate (Huang *et al*., 2018).

It further supports the activities of important immune cells, neutrophils and macrophages. They are important for ruminants to detect and eliminate infections at the beginning stage. Having retinoic acid, induced by Vitamin A, boosts the immune cells' ability to remove bacteria and viruses from the body. Besides, Vitamin A allows natural killer (NK) cells to fight with viruses and cancer cells. Apart from supporting innate immunity, Vitamin A boosts the activities of the adaptive immune system. Retinoic acid encourages the differentiation of regulatory T-cells, which are needed for the body to tolerate the immune system and stay free from long-lasting inflammation. Besides, Vitamin A boosts cell reproduction in B-lymphocytes and helps generate immunoglobulin A, which is vital in mucous secretions. IgA defends against pathogens in the gut and respiratory tracts so they do not have a chance to cause disease. When vitamin A is not present in enough quantities in ruminants, they become more prone to mastitis, pneumonia, and infestations by parasites. It is possible for animals to suffer slow wound healing, long illness recovery, and weaker vaccinations when their antibody production is not optimal. If the mother is deficient in Vitamin A, her newborn calves usually lack strong immunity and do not get the full benefit of colostrum. The studies prove that such weaknesses seriously affect early calf health and the opportunities for survival (Herdt and Stowe, 2004).

Conclusion

Vitamin A is a vital nutrient which is required for the overall health, growth, and productivity of ruminants. It contributes to proper vision, mainly at night, by assisting the production of retinal pigments. It is also important for the good health of epithelial tissues which serve to protect the respiratory, digestive, and reproductive systems. It also supports the immune function by maintaining the mucosal surfaces and helps in white blood cells activity to resist infections.

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