THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212

Popular Article

August, 2023; 3(08), 2186-2192

Role of Vitamin A in Livestock Production

Bharti Yadav[1], Monika Karnani[2], Sheela Choudhary[3], Manju[4]and Praveen Kumar Agrawal[5]
Department of Animal Nutrition
Post Graduate Institute of Veterinary Education and Research (PGIVER), Jaipur
[1] PG Scholar, Department of Animal Nutrition, PGIVER, Jaipur
[2] Assistant Professor, Department of Animal Nutrition, PGIVER, Jaipur
[3] Professor& Head, Department of Animal Nutrition, PGIVER, Jaipur
[4]Assistant Professor, Department of Animal Nutrition, PGIVER, Jaipur
[5]PG Scholar, Department of Animal Nutrition, PGIVER, Jaipur
https://doi.org/10.5281/zenodo.8351928

Abstract

Vitamins being a group of chemically unrelated organic molecules that are needed in minute amounts for different physiological functions. The name “vitamin” originated from the term “vital amine” and refers to a group of compounds having specific roles in metabolism. Vitamins, although organic compounds, do not provide energy like other macronutrients and are not used for the synthesis of structural compounds. However, they function as enzyme precursors, or coenzymes, in different metabolic processes.

Most vitamins need to be provided to the animal in diet, while some of vitamins can be synthesized by the rumen and hindgut microbes or by exposure to sunlight. Deficiency of vitamins in a diet leads to disease conditions, reduced productivity and animal welfare, and reduced immunity in food-producing animals. The dietary requirements of vitamins are very low. Vitamin A is involved in vision, bone growth, reproductive functions, immune responses, and healthy epithelial tissues. Providing sufficient vitamin, A to animals in their balanced diet efficiently increase the milk and meat production in cattle, buffalo, along with good wool and hair quality in sheep, goat while its deficiency and imbalance makes animal susceptible to disease, blindness, and reproductive failure.

Vitamin A

Introduction Prior to the discovery of vitamin A farmers complained that hogs in dry lot did poorly when fed a ration consisting largely of white corn instead of yellow corn. Agriculture chemists would disagree and explained to farmers that chemical analysis showed that white corn and yellow corn were the same with the exception of colour. Then came the vitamin era, which explained that what the farmers already knew, that white corn has no carotene, the precursor of vitamin A (Ensminger and Olentine, 1978).

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published: **29.08.2023**

In 1929, Moore produced proof that the animal body transformed carotene into vitamin A. Animal fed carotene had vitamin A in liver.

Vitamin A deficiency was shown to be responsible for xerophthalmia and certain forms of night blindness. The link between vitamin A and visual process was demonstrated in 1935 when Wald, in a series of experiments, obtained a specific form of vitamin A (Retinal) from bleached retians. In 1944, Morton suggested that retinal from bleached visual purple (Rhodopsin) might be identical with vitamin A aldehyde.

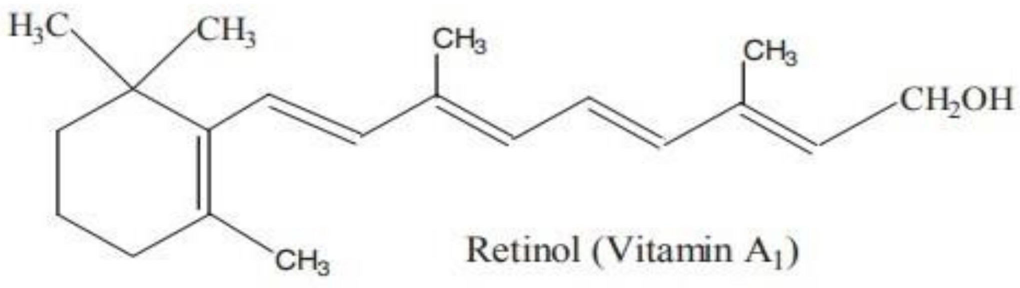
Vitamin A discovered by McCollum and Devis and by Osborne Mendel, independently, 1913. Vitamin A does not exist as a such in plants, but is present as provitamins in the form of certain carotenoids while vitamin A exist only in animal kingdom.

Chemical structure and properties

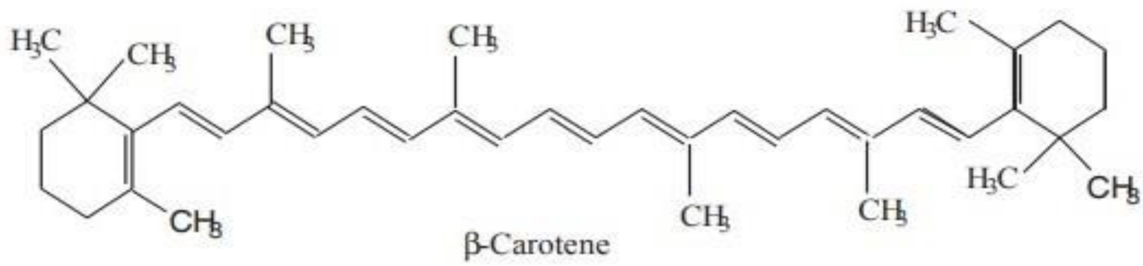
Vitamin A is found only in foods of animal origin. It is present in almost all species of fish, birds and mammals. The yellow plant pigments α, β and γ carotenes and cryptoxanthin are precursors of vitamin A. The body has the ability to convert these carotenoid compounds present in the diet into vitamin A.

The chemical structure of β - carotene is such that it oxidizes to form two molecules of vitamin A, the other provitamins form only one. β -carotene is more efficiently converted to vitamin A than α - or γ - carotene or cryptoxanthin.

There are two forms of vitamin A: Vitamin A1 which occurs in the liver of marine water fish and Vitamin A2 found in the liver of fresh water fish. The vitamin A which contains alcoholic group in the side chain is called as retinol and which contain aldehyde group is known as retinal. Though the two vitamins differ slightly in their chemical structure's vitamin A contain an additional double bond in the β -ionone ring but their physiological functions are the same.



Retinol (Vitamin A_1)



β-Carotene

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published: **29.08.2023**

Vitamin A mostly found in mammalian tissues is the all-Trans vitamin A. Cis forms can arise from the all- Trans forms and a marked loss of vitamin A potency results. These structural changes in the molecule are promoted by moisture, heat, light, and catalysts.

Why vitamin A is important?

Vitamin A is considered by many to be the most important vitamin regarding the need for supplementation. Vitamin A is necessary for proper bone formation, growth, energy metabolism (glucose synthesis) and skin and hoof tissue maintenance, as well as vision. The vision function is associated with visual purple in the eye when animals are trying to adapt from light to dark.

The best source of this vitamin is beta-carotene, a pigment in green plants that animals convert to vitamin A. If cattle are grazing green grass, they will get plenty of vitamin A. During winter months or drought, vitamin A deficiencies are common because dormant plants don't contain the levels of beta-carotene needed compared to the green forage levels in the growing months. Retinol: biologically active form of vitamin A.

Vitamin A is required in the diet of all animals. Vitamin A in the diet can be provided as a vitamin or through its precursor carotenoids present in plants. In animal feeding, most vitamin A is supplied by synthetic sources, which can be produced economically. Carotenoids are the plant form of or the precursor of vitamin A. Carotenoids are pigments present in plant cells (> 600 types) that provide the deep orange/yellow color of plant foods such as carrots, sweet potatoes, and pumpkins. There are two forms of carotenoids: carotenes and xanthophyll. Among these, carotenes (especially β-carotenes) have vitamin A activity. The other carotenoids present in plants (xanthophyll) do not have vitamin activity and are involved in providing color pigments. These types of carotenoids are increasingly used in diets for plumage color enrichment (e.g., exotic birds kept in captivity), egg yolk pigmentation, and aquaculture feeds and in the diets of ornamental fish

Beta carotene: independent of Vitamin A:

Various studies have shown that beta carotene has different function that of Vitamin A as it has specific effect on reproduction along being a precursor of Vitamin A. studies show that dairy cattles receiving extra beta carotene tend to show high intensity of oestrus, increased conception rates, and reduced frequency of follicular cysts. Corpus luteum has high beta carotene concentration than any organ. Friescke (1978) shown that at least 300ug /100 ml plasma for cattle to ensure maximum reproductive efficiency.

Digestion

A number of factors influence digestibility of carotene and vitamin A. Variables that influenced carotene digestibility included month of forage harvest, type of forage (hay, silage, green-chop, or pasture), species of plant, and plant dry matter. In general carotene digestibility was higher than average during warmer months and lower than average during winter.

Absorption and Transport

Much of the conversion of β-carotene to vitamin A takes place in the intestinal mucosa. Provitamin A carotenoids must contain one unsubstituted β-ionine ring to be active. This conversion of β-carotene into vitamin A involve two enzymes. β- carotene-15, 15'-dioxygenase catalyses the cleavage of β-carotene to yield two molecules of retinaldehyde. The second enzyme, Retinaldehyde reductase, reduces the retinaldehyde to retinol.

The cleavage enzyme has been found in many vertebrates but is not present in the cat or mink.

Storage

Liver stores about 90% of vitamin A in hepatocytes and stellate cells in form of retinal ester primarily palmitate and the rest are stored in kidneys, lungs, adrenals, and blood. In some species carotenoids is stored in body as the have ability to absorb and store these precursors.

Sources of Vitamin A

Provitamin A carotenoids, mainly beta carotene in green feeds is principal source of Vitamin A for grazing livestock. All green part of plants is a good indicator of carotene and high vitamin A value. Legume hay are richer in Vat A than grass hay while the plants in later bloom stage and in mature stage losses 50% of their carotene content. Fresh green pasture is the best source of carotenoids for conversion to Vitamin A. Preserved forages such as silage and hay also contain carotenoids, however these are destroyed over time due to temperature, humidity, oxidation so feeds that have been stored for long periods will have lost much of their carotenoid content. Cereal grains such as wheat and barley are very low in carotenoids. In addition, diets that are high in grain inhibit the conversion of carotenoids to vitamin A in the small intestine. Some trace minerals are detrimental to Vitamin A stability in feed and premixes but recently uses of chemical stabilizers, antioxidants, emulsifying agents, gelatine, sugar beaded and prilled products have improved its stability but still its storage is not much advised

Function

Vitamin A is required growth health and general maintenance of life of animals. Physiologically mainly Vitamin A performs 4 major functions. A study done on rat's shows that acid form of Vitamin A retinoic acid can perform all general function of Vitamin A EXCEPT vision.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published: 29.08.2023

1. **Vision:** vitamin A is an essential component in vision as needed in resynthesize in rhodopsin as result of photochemical reaction where some vitamin A lost and is replaced by Vitamin A from blood this showed any fluctuation in blood vitamin A functionally affects the vision causes night blindness.

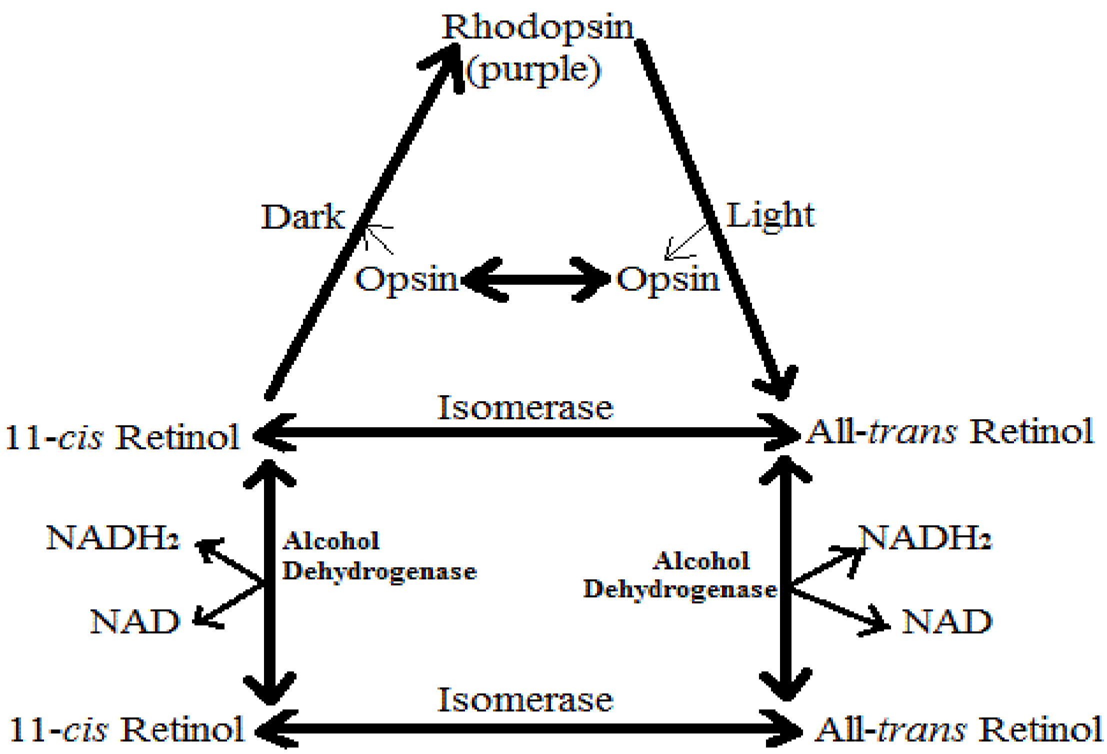


Fig. Depicting the role of retinol in the visual cycle

2. Maintenance of normal epithelium: vitamin A is to maintain epithelial cells which form protective lining of body organs like respiratory, intestinal and urogenital tract by the normal mucous secreting epithelial cells inadequate vitamin A replaces mucous cells stratified keratinized epithelium making it susceptible to infection and reduces the resistance to stress and disease.
3. Reproduction: inadequate vitamin A dramatically affects reproductive ability. In hens hatchability is significantly reduced while its deficiency increases incidence of abortion in pregnant does in male its deficiency decline sexual activity libido and failure of spermatogenesis due to degeneration of germinal epithelium and seminiferous tubule and ceases the sperm formation
4. Bone development: Vitamin A has a control over the activity of osteoblast and osteoclast of epithelial cartilage leading to disorganized bone growth and joints irritation in its deficient.in

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published: **29.08.2023**

some cattle sheep and swine it also shows nervous symptom due to increased cerebrospinal fluid pressure due to reduced bone growth of skull.

5. Immunological response and disease condition: Vitamin A deficient animal shows increased incidence of bacterial protozoal and viral infections due to affected functioning of protected lining in chicks' atrophy of thymus and spleen making prone to tetanus and diphtheria vitamin A aids in curing ringworm infection in cattle dog and sheep and lungworm infection in sheep.

Deficiency symptoms of vitamin A

1. Night blindness (Nictalopia): Deficiency of vitamin A first manifest as a slow, dark adaptation and progresses to total blindness.
2. Xerophthalmia (from Latin words for dry eye): This is an advance stage of vitamin A noted particularly in children, dogs, and rats. It is characterized by a dry condition of the cornea and conjunctiva, cloudiness and ulceration.
3. Keratinization of epithelium: Normal epithelium (columnar epithelium) in various locations of the body became replaced by a stratified squamous, keratinizing epithelium (cornified cells). Epithelial cells from deficient animals fail to differentiate beyond the squamous type to the mucous secreting cells and mesenchymal cells fail to differentiate beyond the blast stage. This effect has been noted in the respiratory, alimentary, reproductive and genitourinary tract, as well as in the eye. So respiratory troubles such as cold and sinus infections and gastrointestinal disorder such as diarrhoea tend to be more severe in vitamin A deficiency since vitamin A deficiency lower the resistance to infections.

In poultry Nutritional ROUP characterized by mucopurulent rhinitis and respiratory tract occlusion keratomalacia and xerophtlalamia because of dried tear glands resulted by keratinization of tear membrane.

1. Reproductive performance: There is a specific interference with reproduction caused by the altered epithelium. Poor conception rates / infertility, due to quality of semen in males, and ability of females to conceive and maintain pregnancies. In the female estrus is disturbed, if the deficiency is severe, abortion or birth of dead, weak or abnormal offspring may occur.

In poultry egg production and hatchability of fertile eggs are markedly reduced.

2. Nervous lesion: Skeletal growth is retarded in young animals but nervous tissue and brain grow and hence there is pressure on nervous tissue. Increase cerebrospinal fluid pressure has been observed in vitamin A deficient chicken, cattle, etc.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published: **29.08.2023**

Supplementation

In animal diet vitamin A is effectively supplied by including it with concentrate mixture that provide uniform consumption while in grazing livestock Vitamin A is given as a free choice mineral mixture as alternative to mixing with feed. Ingredient to blend with dry feed. Vitamin A is often given along with Vitamin D& E in liquid feed supplements with molasses, fat, urea, and selected minerals.

In recent times livestock are given intramuscular injection of Vitamin A concentrate. Feed lot cattle are given Vitamin A (1000000 IU) as a pre conditioning process. Mega dose are given in drinking water or injection it treating diseased and convalescent animals.

1 Calves:	200000-500000 IU per animal
2 Cattle:	1000000-1500000 IU per animal
3 Breeding Bulls:	2000000-3000000IU per animal
4 Sheep (Rams):	100000-500000 IU per animal
5 Sheep (Ewes):	1000000 IU per animal

"Adapted from Hoffman Laroche (1967)

Toxicity

Being a fat-soluble vitamin, long-term consumption of vitamin A may lead to toxic symptoms. However, symptoms will vary with species, age, and physiological condition. However, presumed safe levels are 4 to10 times the nutritional need in non-ruminants while it is 30 times more in ruminants. Characteristically skeletal abnormalities and thickening of the skin internal hemorrhage spontaneous fractures conjunctivitis keratinization are reported in hypervitaminosis. Excess vitamin A typically shoe fatty infiltration of liver and kidney and interfere with absorption of other vitamin absorption. Bone abnormalities including extensive bone resorption and narrowing of bone shaft bone fragility, short bones and retarded growth. In hypervitaminosis A, retinol penetrates lipid of membrane and causes to expand it and as protein membrane is inelastic it weakens the membrane and damage the cell organelles affects the functional activity.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published: **29.08.2023**

Conclusion

Vitamin A role in vision, epithelial tissue mucus membrane, nervous tissue, bone growth and immune response makes it one of the vital vitamins needed by animals for the efficient production and reproduction along with maintaining general health. But sometimes its excess consumption leads to hypervitaminosis affecting majorly liver and kidney along with bone abnormalities.

References

Albers, N, Gotterbarm, G, Heimbeck ,W, *et al*., vitamins in animal nutrition, vitamins and their biological functions, awt agrimedia, Germany, p. p 10,11.

C. G., (2019). A Guide to the principles of animal nutrition: vitamin. Oregon state university Corvallis, United States, pp 89-91.

Case, L.P., L. Daristotle., M.G. Hayek., and M. F. Raasch. 2011.

Canine and Feline Nutrition. 3 rd ed. Mosby Elsevier, MO, USA. Cheeke, P.R., and E. S. Dierenfeld.

Comparative Animal Nutrition and Metabolism. 2010. CABI. Boston, MA, USA. Fooks, L. J., and G. R. Gibson. 2002. Probiotics as modulators of the gut flora. Br. J Nutr 88 (Suppl 1):S39-S49.

Ensminger, C.G., Olentine M.E., (1978): -feed and nutrition-Abridged, The Ensminger,

International Union of Pure and Applied Chemists (IUPAC), Nomenclature of retinoids. Recommendations 1981, in: IUPAC-IUBMB Joint Commission on Biochemical Nomenclature and Nomenclature Commission of IUBMB, 2nd edition, Lie´becq, C., editor, Portland Press, 1992, http:==www.chem.qmul.ac.uk=iupac=misc=ret.html.

McDowell, lee. Vitamins in animal nutrition comparative to human nutrition, vitamin A, ACADEMIC PRESS, California, p. p 305-308

Reddy, D. V., principles of animal nutrition and feed technology, 3rd edition, the vitamins 12, CBS New Delhi, p. p 10-52.

Sporn, M.B. and Roberts, A.B., Introduction: What is a retinoid? in: Retinoids, Differentiation, and Disease, Pitman: London, 1985, p. 1.

Wolf, G., A history of vitamin A and retinoids. FASEB J. 10, 1102, 1996.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published: **29.08.2023**