

# Carotenoids in Farm Animal Diets: Implications for Health and Performance - A Review

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## Abstract

Carotenoids are naturally occurring pigments found in various plants and algae, which play essential roles in the health and performance of farm animals. This review aims to provide a comprehensive analysis of the implications of carotenoids in farm animal diets on health and performance. Carotenoids have been recognized for their antioxidant properties, immunomodulatory effects, and potential for enhancing reproductive performance. Moreover, these compounds contribute to the vibrant colors of animal tissues, which have aesthetic value and can impact consumer perception. The review encompasses an examination of carotenoid sources, absorption and metabolism in farm animals, and their effects on growth, immunity, reproduction, and product quality. Additionally, potential mechanisms underlying the observed benefits are discussed. Overall, a better understanding of the role of carotenoids in farm animal diets can guide feed formulation strategies, promoting optimal animal health, performance, and product quality.

**Keywords:** Carotenoids • Farm animals intake • Health and performance

## Introduction

Carotenoids are natural pigments widely present in plants and algae, responsible for the vibrant colors seen in various fruits, vegetables, and flowers. These compounds have gained significant attention due to their potential health benefits and physiological functions in animals, including farm animals. Carotenoids can be obtained through dietary sources or synthesized by certain animals, while others rely on external dietary intake. In farm animal production, the inclusion of carotenoids in animal diets has garnered interest as a means to enhance health, performance, and product quality. Carotenoids have been recognized for their antioxidant properties, which play a crucial role in combating oxidative stress and promoting overall well-being. Additionally, they have immunomodulatory effects, potentially improving immune responses and disease resistance in animals. Furthermore, carotenoids contribute to the visual appeal of animal tissues, affecting consumer perception of product quality. The characteristic red, orange, and yellow colors imparted by carotenoids in animal-derived products, such as eggs and meat, can influence consumer preferences and willingness to purchase.

Understanding the implications of carotenoid inclusion in farm animal diets is vital for optimizing animal health, performance, and product quality. Therefore, this review aims to comprehensively examine the potential health benefits of carotenoids in farm animals, as well as their impacts on growth, immunity, reproduction, and product quality. Moreover, this review explores the underlying mechanisms behind the observed effects and discusses challenges and future perspectives in utilizing carotenoids in farm animal production [1,2].

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## Literature Review

### Sources and types of carotenoids in farm animal diets

Carotenoids in farm animal diets can originate from various sources, including natural feedstuffs and synthetic supplements. Natural sources of carotenoids include green forages, vegetables, fruits, and certain algae. Common carotenoid types found in these sources include  $\beta$ -carotene, lutein, zeaxanthin, lycopene, and astaxanthin. Additionally, carotenoid-rich byproducts from the food and agricultural industries, such as marigold petals and tomato pomace, are often utilized as feed ingredients. Synthetic carotenoid supplements derived from chemical synthesis or fermentation processes are also available. The selection of carotenoid sources and types in farm animal diets depends on factors such as cost, availability, stability, and desired physiological effects [3]. Careful consideration of these factors is essential to ensure optimal carotenoid inclusion and achieve desired health and performance outcomes in farm animals.

**Natural sources of carotenoids:** Carotenoids, the pigments responsible for the vibrant colors seen in various fruits, vegetables, and plants, are abundant in natural food sources. Green forages, such as grasses and leafy vegetables, are rich sources of carotenoids like  $\beta$ -carotene, lutein, and zeaxanthin. Brightly colored fruits and vegetables like carrots, tomatoes, papayas, and pumpkins are also notable sources of carotenoids, including  $\beta$ -carotene and lycopene. Additionally, certain algae species, such as *Spirulina* and *Dunaliella*, contain high concentrations of carotenoids, such as  $\beta$ -carotene and astaxanthin. These natural sources offer a diverse range of carotenoids that can be incorporated into farm animal diets to provide various health benefits and enhance product quality.

**Major carotenoid types and their distribution in feedstuffs:** Feedstuffs contain a variety of carotenoid types that contribute to the nutritional composition of animal diets.  $\beta$ -carotene, lutein, zeaxanthin, lycopene, and astaxanthin are among the major carotenoids found in feed ingredients.  $\beta$ -carotene is commonly present in green forages, such as grasses and leafy vegetables. Lutein and zeaxanthin are prevalent in yellow and orange fruits and vegetables, while lycopene is abundant in tomatoes and other red-colored fruits. Astaxanthin, a highly potent carotenoid, is found in certain algae species and marine organisms. Understanding the distribution of these carotenoids in feedstuffs enables feed formulators to select appropriate ingredients to meet the specific carotenoid requirements of farm animals [4].

## Absorption, metabolism and bioavailability of carotenoids in farm animals

The absorption, metabolism, and bioavailability of carotenoids in farm animals play a crucial role in determining their efficacy and health benefits. Understanding these processes is essential for optimizing carotenoid utilization in animal diets.

**Absorption:** Carotenoid absorption in farm animals primarily occurs in the small intestine. The presence of dietary fat enhances their absorption, as carotenoids are lipid-soluble compounds. Emulsification and micellarization facilitated by bile salts are important steps in carotenoid absorption. The efficiency of carotenoid absorption can vary depending on factors such as carotenoid structure, dietary composition, and animal species.

**Metabolism:** Once absorbed, carotenoids undergo metabolism in the intestinal mucosa and liver. The initial step involves cleavage of carotenoid molecules by enzymes, leading to the formation of smaller fragments called apocarotenoids. These apocarotenoids can be further metabolized into various compounds, such as retinoids or excreted as bile pigments. The metabolism of carotenoids in farm animals can vary depending on species-specific enzymatic activities and regulatory mechanisms.

**Bioavailability:** Carotenoid bioavailability refers to the fraction of ingested carotenoids that is absorbed and available for physiological functions. Bioavailability can be influenced by several factors, including carotenoid source, feed processing methods, presence of dietary factors, and interactions with other nutrients [5]. The bioavailability of carotenoids can vary among different carotenoid types, with some being more readily absorbed and utilized than others.

**Factors affecting bioavailability:** Several factors can affect the bioavailability of carotenoids in farm animals. The presence of dietary fibers can reduce carotenoid absorption by interfering with their release from plant matrices. Conversely, dietary lipids and fats can enhance carotenoid absorption due to their role in micellarization and solubilization. Feed processing methods, such as heat treatment or particle size reduction, can impact carotenoid stability and bioaccessibility. Additionally, interactions with other nutrients, such as vitamins E and C, can influence carotenoid absorption and utilization.

**Species-specific differences:** Different farm animal species exhibit variations in carotenoid absorption, metabolism, and bioavailability. For instance, monogastric animals, such as pigs and poultry, have limited capacity to convert dietary carotenoids to vitamin A and are more efficient at absorbing intact carotenoids. Ruminants, on the other hand, possess ruminal microbial populations capable of synthesizing carotenoids, which can contribute to their total carotenoid pool.

## Health benefits of carotenoids in farm animals

Carotenoids offer numerous health benefits to farm animals, contributing to their overall well-being and performance. Some of the key health benefits include:

**Antioxidant activity:** Carotenoids act as potent antioxidants, neutralizing harmful free radicals and protecting cells from oxidative damage. This antioxidant activity helps to maintain cellular health, supports immune function, and reduces the risk of chronic diseases.

**Immunomodulatory effects:** Carotenoids have been found to modulate immune responses in farm animals. They can enhance immune cell function, promote the production of antibodies, and improve immune defense mechanisms. This immunomodulatory effect contributes to improved disease resistance and reduced susceptibility to infections.

**Reproductive performance:** Carotenoids play a crucial role in reproductive health and fertility in farm animals. They support proper hormonal regulation, enhance sperm quality, improve oocyte health, and contribute to successful reproductive outcomes.

**Gut health and microbiota:** Carotenoids have been shown to positively influence gut health in farm animals. They promote the growth of beneficial gut

bacteria, improve intestinal integrity, and support a healthy gut microbiota. This can lead to better nutrient absorption, enhanced digestion, and reduced risk of gastrointestinal disorders [2].

**Respiratory health:** Certain carotenoids, such as  $\beta$ -carotene, have been associated with improved respiratory health in farm animals. They can protect lung tissues from oxidative damage, support lung function, and reduce the incidence and severity of respiratory diseases.

By incorporating carotenoids into farm animal diets, producers can harness these health benefits to optimize animal well-being, improve disease resistance, enhance reproductive performance, and promote overall productivity and profitability in their operations.

## Discussion

### Carotenoids and animal performance

Carotenoids have been recognized for their potential to enhance animal performance in various aspects [6]. Their inclusion in farm animal diets can have positive effects on growth, reproductive performance, and product quality, thereby improving overall animal productivity. Here are some ways carotenoids contribute to animal performance:

**Growth performance:** Carotenoids, particularly certain types like  $\beta$ -carotene, have been associated with improved growth performance in farm animals. They play a role in enhancing nutrient utilization, supporting efficient metabolism, and promoting optimal growth rates. Carotenoids may positively influence factors such as feed conversion efficiency, body weight gain, and skeletal development, leading to improved growth performance.

**Reproductive performance:** Carotenoids are known to play a crucial role in reproductive health and fertility in animals. They contribute to proper hormonal regulation, follicular development, and sperm quality, which can lead to enhanced reproductive performance. Carotenoids like lutein and zeaxanthin have been associated with improved ovulation, embryo quality, and successful pregnancy outcomes in various species.

**Product quality:** Carotenoids have aesthetic benefits and can enhance the quality of animal-derived products, such as eggs, meat, and milk. The deposition of carotenoids in tissues can impart desirable coloration, such as the vibrant yellow-orange yolks in eggs, which can influence consumer perception and preference. In addition to color enhancement, carotenoids can also contribute to improved texture, flavor, and nutritional value of animal products [7].

**Oxidative stress management:** Carotenoids possess antioxidant properties, which help in managing oxidative stress in animals. By scavenging free radicals and protecting cells from oxidative damage, carotenoids support overall cellular health, reduce oxidative stress-induced inflammation, and improve the functioning of vital organs. This antioxidant activity contributes to improved overall health and well-being of animals, which in turn can positively impact performance outcomes.

It is important to note that the effects of carotenoids on animal performance can vary depending on factors such as species, breed, dosage, and overall diet composition. Proper formulation and inclusion of carotenoids in farm animal diets, considering these factors, can maximize the potential benefits and optimize animal performance.

### Mechanisms underlying the health benefits of carotenoids

The health benefits of carotenoids in farm animals are attributed to several underlying mechanisms. Carotenoids act as antioxidants, neutralizing harmful free radicals and reducing oxidative stress. They also modulate immune responses, enhancing immune cell function and promoting disease resistance. Carotenoids support reproductive health by influencing hormone regulation and improving reproductive outcomes. Additionally, they contribute to gut health by promoting beneficial gut bacteria and maintaining intestinal integrity [8]. These mechanisms collectively contribute to the overall well-being, performance, and

productivity of farm animals, making carotenoids an essential component of their diets.

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## Conclusion

The inclusion of carotenoids in farm animal diets holds significant potential for enhancing animal health, performance, and product quality. Carotenoids offer various health benefits, including antioxidant activity, immunomodulation, reproductive support, and promotion of gut health. These benefits are attributed to their antioxidant properties, immune-enhancing effects, and modulation of physiological processes. By understanding the mechanisms underlying the health benefits of carotenoids and considering factors such as absorption, metabolism, and bioavailability, farmers and feed formulators can optimize carotenoid utilization in animal diets. Incorporating carotenoids into farm animal feeding strategies has the potential to improve growth rates, reproductive outcomes, disease resistance, and the quality of animal-derived products. Overall, carotenoids play a valuable role in promoting the well-being and productivity of farm animals.

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Not applicable.

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## Conflict of Interest

There is no conflict of interest by author.

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