

# Efficacy of Microalgal Biomass in Poultry Nutrition

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## ABSTRACT

The rapid growth of chicken broilers, the availability of its high-quality meat at low sales prices, and its rapid response to changes in ration composition have increased the researchers attention to producing chicken meat enriched with functional ingredients. Microalgae can be efficiently used in poultry nutrition to enhance the pigmentation and nutritional value of meat and eggs, as well as partial replacement of conventional dietary protein sources. Spirulina (*Athrospira sp.*) is an edible microalga and a highly nutritious potential feed resource for many agriculturally important animal species. Research findings have associated Spirulina to improvements in biomass, chicken meat colour, chicken meat quality and egg quality. Spirulina intake has also been linked to an improvement in health and welfare. Its influence over animal development stems from its nutritive and protein-rich composition, thus leading to an increased commercial production to meet consumer demand. Consequently, Spirulina is emerging as a cost-effective means of improving poultry productivity for a sustainable and viable food security future. In this review, we unveil the use of microalgae as a feed ingredient in poultry nutrition.

**Keywords:** Poultry nutrition; Microalgae; Spirulina; Nutritional value

## INTRODUCTION

Microalgae, or microscopic algae, are unicellular photosynthetic organisms that can grow in both salt and fresh water. They have a long tradition of use as a human food due to their high content of nutrients and biologically active substances such as protein, amino acids, n-3 long chain polyunsaturated fatty acids (LCPUFA n-3), microelements, vitamins, enzymes, and carotenoids [1]. 'Algae' is a generic term that groups brown, green, and red types of both macro- and micro-algae. These marine plants may play a key role in the future for poultry production, as they constitute a new and valuable nutrient source, thanks to their nutritional composition and richness in as polyphenols, polysaccharides and fatty and amino acids. Microalgae, or microscopic algae, have been investigated as a natural aquatic resource for a variety of commercially viable uses, including animal feed. The growing demand for human protein food supplies has necessitated the development of new feed materials that provide poultry and livestock with a healthy supply of nutrients. Several feeding trials have shown that microalgae of various species can be successfully included into poultry diets, for example as a defatted biomass byproduct from biofuel production, and can have a beneficial influence on birds' health, performance, and the quality of meat and eggs. Especially important for the poultry industry are recent studies where microalgal biomass was efficiently used in the production of eggs containing health-promoting lipids, i.e. eggs enriched with health promoting Long-

Chain n-3 Poly Unsaturated Fatty Acids (LCPUFAs n-3). In this review, we unveil the dietary microalgae effects currently known on production and meat quality of livestock species (ruminants, pigs, poultry and rabbits). Many studies have evaluated the advantages and inconvenience of using micro- and macro-algae in poultry nutrition and their ability to improve animal health and, thus, welfare. Some algae are also rich in omega-three fatty acids and may contain vitamins or pigments such as chlorophyll and carotenoids, which can help influence the colour of egg yolks. Composition of certain types of microalgae compared more conventional European feed sources are given the Table 1.

**Table 1:** Composition of certain types of microalgae compared more conventional European feed sources.

Source	Crude protein	Carbohydrates	Fat
Soy beans	37	30	20
Corn	10	85	4
Wheat	14	84	2
<i>Anabaena cylindrica</i>	43-56	25-30	4-7
<i>Arthrospira maxima (Spirulina)</i>	60-71	13-16	6-7
<i>Chlorella vulgaris</i>	51-58	12-16	14-22
Spirogyra sp.	6-20	33-64	11-12

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Spirulina is cultivated worldwide for use in the food and feed industries. Spirulina (*Arthrospira* sp.) is an edible, filamentous, spiral-shaped cyanobacterium, formally classified as a blue-green microalga [2-4]. It is naturally found in the alkaline lakes of Mexico and Africa [1,5]. These microalgae are known as cyanobacteria because of their prokaryotic cell form, and they are divided into two species: *Spirulina platensis* and *Spirulina maxima*. The nutritional importance of dried Spirulina biomass for humans and animals is high since it contains around 60-70 percent protein and is a good source of essential fatty acids, vitamins, and minerals [6]. Spirulina is a rich source of carotenoids and contains around 6,000 mg total xanthophyll and 7,000 mg total carotenoids/kg in freeze-dried biomass [7].

In recent work, Evans et al. showed that dried full-fat Spirulina algae had an energy value equal to 90% the energy of corn (2839 kcal TME<sub>n</sub>/kg), as well as containing a high level of crude protein (76%) and essential amino acids [8]. They also reported that “up to 16% of dried algae can be incorporated into a broiler starter diet without any negative effects on the performance of chicks. Similar results were obtained in work” by Ross and Dominy who found no significant differences in performance of broilers fed a diet containing 1.5, 3, 6 or 12% dehydrated Spirulina in feed [9]. They concluded that Spirulina at up to 12% of the diet may be substituted for other protein sources in broiler diets with good growth and Food Conversion Ratio (FCR). Toyomizu et al. reported no difference in growth performance of broilers fed with or without 4 or 8% of Spirulina biomass in the diet [10]. There was no disparity in growth efficiency between broilers fed 4 or 8 percent Spirulina biomass in their diets. However, as the nutritional level of microalgae grew, the yellowness of muscles, skin, fat, and liver increased, making it more desirable to customers in many countries. As a result, dietary Spirulina can be used to manipulate the colour of chicken meat, especially in the range where the fillets produced by feeding Spirulina do not fall under the extremes of either dark or light meat [10]. Similar results were reported by Venkataraman et al. “dried Spirulina (included at 14 or 17 percent in the diet) had no impact on broiler efficiency, dressing percentage, or histopathology when used as a supplement for dietary fish meal or groundnut cake protein [11]. In the case of birds fed algal-supplemented diets, however, they discovered a more intense meat colour”. In contrast to the above authors, Shanmugapriya et al. recently observed improved Body Weight Gain (BWG), FCR and villus length in broilers fed a diet containing Spirulina biomass [12]. Spirulina biomass at a low dietary level (0.02 to 0.03 percent) improved broiler consistency, increased dressing percentage, meat colour ranking, lymphoid organ weight, improved blood morphology, and decreased relative abdominal fat weight, blood cholesterol, triglycerides, and total lipids by Marley et al. [13].

## CHICKEN MEAT COLOUR

Customers use meat colour as one of the most significant considerations in selecting fresh meat products. Consumers' meat preferences are influenced by the colour and flavour of the meat. Dietary Spirulina is useful for modifying the colour of chicken meat, particularly because the fillets created by feeding Spirulina do not fall into either the dark or light meat extremes. It was observed that Spirulina-fed breast filets were darker, redder and more yellow in colour which is likely a result of the high amounts of carotenoids in the microalgae [14]. Toyomizu et al. found that including Spirulina in broiler feeds influenced both the yellowness

and redness of broiler meat [10]. They speculated that the rise in yellowness associated with dietary Spirulina consumption may be mirrored in the common yellow pigment associated with zeaxanthin accumulation in the meat. Dietary Spirulina can be used to manipulate the colour of chicken meat within a range where the fillets formed by feeding dietary Spirulina do not fall into either the dark or light meat categories. Dietary Spirulina levels at 1% of the total ration in the week prior to slaughter have been found to result in broiler muscle tissue pigmentation at levels best representing consumer preferences [15].

## CHICKEN MEAT QUALITY

Chicken meat is widely eaten around the world, with recent years seeing an increase in demand. It has been shown that the shelf-life of meat is largely determined by storage conditions and the animal's life cycle prior to slaughter. Meat is prone to oxidative degradation in general and lipid oxidation in particular, which influences colour, flavour, odour, texture, and nutritional value. The lipid oxidation is frequent in poultry due to the high content of Polyunsaturated Fatty Acids (PUFA). Several studies focused on the effects of feed supplementation in improving the oxidative stability of the poultry tissue.

Park et al. reported that birds fed with Spirulina showed significantly lower drip loss as dietary levels of Spirulina increase [16]. The effects on meat quality resulting from Spirulina protein in poultry diets are studied by Altmann et al. [14]. Spirulina-fed samples were less metallic in flavour and the two alternative feed groups were softer and more tender than the control group. El-Bahr et al. recommended supplementation of the *S. platensis* to broilers chickens' diet for improvement of performance parameters, profiles of fatty and amino acids, antioxidant status and meat quality [17]. Similarly, Pestana et al. Breast and thigh meats from chickens fed with Spirulina, with or without the inclusion of exogenous enzymes, had higher values of yellowness, total carotenoids, and saturated fatty acids, according to the influence of Spirulina as a feed ingredient (15 percent incorporation) in broiler diets [18]. Broilers fed Spirulina, particularly at 1% and 2%, had significantly lower serum cholesterol, triglyceride levels and total lipid as compared with control [19]. Effect of dietary Spirulina in broiler chicken had enriched fatty acid profile of the thigh meat especially eicosapentaenoic acid and docosahexaenoic acid after Spirulina supplementation [20].

## EGG QUALITY

Laying hen nutrition is critical for achieving optimal egg production and flock health, and special attention is paid to the source, content, and quality of protein in feeds. Spirulina is fed to the hens to improve the consistency of their eggs. Egg quality is a significant feature of poultry processing that has an effect on production viability and customer loyalty. Marley et al. reported that dietary incorporation of 0.1%, 0.15% and 0.2% Spirulina increased the laying rate, egg weight and egg mass [21]. Spirulina at a concentration of 0.3% is a functional natural feed additive to improve laying performance, egg quality and hepatoprotective activity of hens [22]. Spirulina-based diet increases the polyunsaturated fatty acids (PUFAs) content and reduces amounts of cholesterol in eggs [23].

## CONCLUSION

After reviewing the available literature, it can be inferred that,

while the chemical structure of various microalgal biomasses varies, many can be safely added to poultry diets. Several other microalgae organisms, such as *Spirulina*, can be used to improve the pigmentation and nutritional content of meat and eggs for human consumption, such as by adding LCPUFA n-3 and carotenoids, for example, as well as to partially replace conventional protein sources, mainly soybean meal.

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