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Ascophyllum nodosum as a growth promoter in poultry: Meta-analysis

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ABSTRACT

The increasing global demand for protein demand for efficient and sustainable strategies in poultry industry. One of the latest advancements is the use of seaweeds as economic feed for poultry. The seaweed *Ascophyllum nodosum*, a brown seaweed has much potential due to its bio-active compounds and aid body weight growth in poultry. This meta-analysis examines its efficiency in terms of body weight across the species of broiler and age groups. A comprehensive literature search was conducted across NCBI (521 results) and Google Scholar (2,480 results), with studies screened for relevance based on inclusion criteria for meta-analysis. Using 27 unique study point from the finalized literature, standard mean differences (Hedges' d) were calculated to assess the effect size. The meta-analysis revealed a robust and significant positive effect of *A. nodosum* supplementation on poultry body weight, with a pooled effect size of d = 1.705 (95% CI: 0.907 to 2.503, p < 0.001). A high heterogeneity was observed (I^2 = 98.85%, Q = 2254.834, p < 0.001). *Ascophyllum nodosum* supplementation significantly enhance broiler body weight. However, further studies are needed to explore factors influencing its efficacy, such as environmental conditions, management, and extracts.

Introduction

Balanced protein supply with sustainable production practices is critical for poultry industry to meet the increasing global demands hence optimized nutritional strategies have become increasingly important (Moughan, 2021). Poultry industry is under stress for efficient production and economically optimized approaches as the global demand is rising with the increase in population and the demand for nutrition-based strategies is spiking (Kleyn and Ciacciariello, 2021). In recent times, a large research interest has been focused on natural feed additives, particularly marine resources owing to their potential and applicability in poultry nutrition (Placha and Pogány Simonová, 2022; El-Sabrout *et al*., 2023). *Ascophyllum nodosum*, a brown seaweed has emerged as a promising natural product as broiler feed supplementation agent (Bonifait *et al*., 2022; Dewi *et al*., 2024).

Incorporated with abundance of bioactive compounds such as polysaccharides (fucoidan, laminarin, alginates), polyphenols, essential minerals, and vitamins, *Ascophyllum nodosum* exhibits antioxidant, anti-inflammatory, antimicrobial, and prebiotic properties that work to enhance nutrient utilization, gut health, increased body weight, and immune function in broilers (Venardou *et al*., 2021; Archer, 2023; Ummat *et al*., 2024). Additionally, the bioactive compounds of *Ascophyllum nodosum* modulate the beneficial microbiome of broilers resulting in improved digestion, better feed utilization, and nutrient absorption (Bonifait *et al*., 2022; Oretomiloye and Adewole, 2024).

The brown seaweed *Ascophyllum nodosum* is gaining attention as a natural feed additive due to its bioactive compounds that may enhance broiler growth, immunity, and nutrient utilization (Oretomiloye and Adewole, 2024). However, existing studies report inconsistent effects on performance traits, creating uncertainty about their efficacy.

New findings in chicken nutrition have shown the capacity of feed additives such as *Ascophyllum nodosum* to increase production and sustain health at the molecular level via immune and antioxidant pathways. Its bioactive substances, notably polyphenols and fucoidan, have demonstrated highly favorable and promising prospects in dealing with oxidative stress and lowering inflammation, which tend to be positive influences in high-performance broiler production systems. (Kwak *et al*., 2024). Also, the advancements in supplementation methods like encapsulation, have increased their reflectivity in many folds via bioavailability, assuring their accurate delivery in the gastrointestinal tract for maximal efficacy. These characteristics put *A. nodosum* in a favorable position that can tackle the constraints encountered in modern poultry production as a sustainable substitute for conventional growth stimulants (Elolimy *et al*., 2025). This study aimed to determine the effects of *Ascophyllum nodosum* supplementation on broiler body weight performance by analysis the published literature reporting the varying or dispersed effects via met-analysis technique. This meta-analysis will provide significant information for poultry nutritionists and industry stakeholders, supporting sustainable, natural feed additives to improve broiler productivity while reducing reliance on synthetic alternatives.

Materials and methods

Literature search and study selection

Adhering to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, this meta-analysis ensured a comprehensive literature search conducted across databases such as PubMed and Google Scholar to identify studies examining the effects of *Ascophyllum nodosum* supplementation on broiler body weight (Fig. 1). The search incorporated keywords including "*Ascophyllum nodosum*," "brown seaweed," "broiler performance," "body weight gain," and "poultry nutrition."

Limiting inclusion to rigorous studies, this meta-analysis considered only those studies that involved broilers, supplementation of *Ascophyl-*

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lum nodosum as a dietary additive, reporting body weight or weight gain, utilizing a controlled experimental design, and providing sufficient statistical data. Studies were excluded if they lacked a control group, combined *A. nodosum* with other additives without separate evaluation, or failed to report adequate statistics. Duplicate articles were removed, and two independent authors screened titles, abstracts, and full texts, resolving disagreements through discussion or consultation.

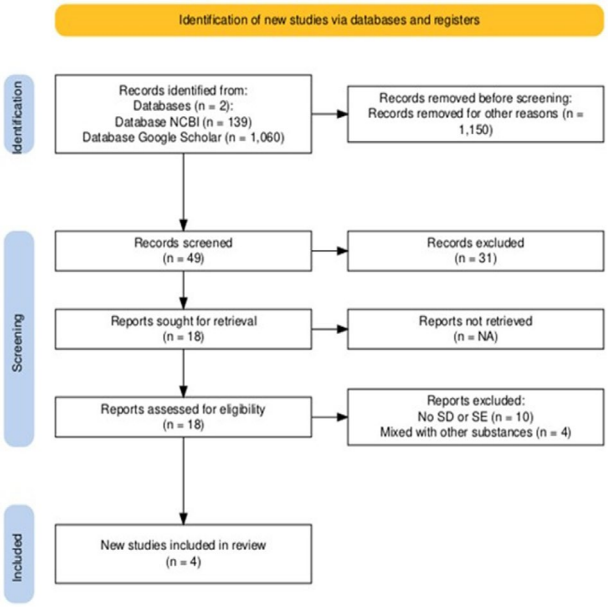

Fig. 1. The following PRISMA flowchart outlines the systematic process of literature selection, starting from the initial database search, removal of duplicates, and screening of titles and abstracts, followed by full-text assessment and final inclusion of studies for meta-analysis. It ensures transparency in study selection and minimizes bias.

Data extraction and coding

All relevant data were extracted from each selected study (Table 1), including general study details (first author name, publication year), experimental design (number of broilers per control and treatment group), dietary treatments (*Ascophyllum nodosum* inclusion level), statistical data (Standard deviations) and outcome variables (final body weight in grams). All information was systematically recorded in a standardized spreadsheet, with an independent reviewer verifying the entries to ensure accuracy.

Statistical analysis

Heterogeneity (via Cochran's Q test and the I^2 statistic) and the meta analysis was carried out using the OPENMEE software to compute the effect sizes and reliability. The standardized mean difference (SMD) (95% CI) was used for the SMD assessment.

Publication bias assessment

The help of OPENMEE software for meta-analysis was utilized to assess publication bias through the Fail-Safe N test, via Rosenthal's method.

Results

Standard Meta Analysis for Effect of Ascophyllum nodosum on Body Weight

Examining the 27 unique study points via meta-analysis, gives us insights into the effects of *Ascophyllum nodosum* supplementation on broiler body weight. The standard mean difference SMD was estimated at 1.705 (95% CI: 0.907 to 2.503, $p < 0.001$) between the control and treatment groups. The SMD of 1.705 indicated a clear significant and positive impact of *A. nodosum* on the body weight in broilers.

Demonstrated by ($Q= 2254.834$, $df= 26$, $p < 0.001$, $I^2= 98.847\%$), a substantial heterogeneity is reported. This indicates a substantial variability in the treatment effects across the experimental trials possibly via various inclusion levels of *A. nodosum*, breed, or other factors.

Publication bias assessment

The fail-safe N analysis, conducted using the Rosenthal method, yielded a fail-safe N of 8488, indicating that an additional 8488 unpublished or null-effect studies would be required to reduce the observed effect to non-significance ($p \geq 0.05$) . This exceptionally high value suggests that the significant effect of *Ascophyllum nodosum* supplementation on broiler body weight is robust and unlikely to be due to publication bias.

Discussion

The standard mean difference SMD between the control trials and treatment trials 1.705 (95% CI: 0.907 to 2.503, $p < 0.001$) shows a significant enhancement of body weight as under supplementation of *Ascophyllum nodosum* (Oretomiloye and Adewole, 2024). These findings align with previous studies highlighting the beneficial effects of *A. nodosum* on poultry growth, attributed to its rich composition of bioactive compounds such as polysaccharides, polyphenols, essential minerals, and vitamins (Bonifait *et al*., 2022; Archer, 2023). This suggests the positive and considerable role of seaweed in the broiler industry, the substantial heterogeneity however, underscores the variability among the outcomes reported in the literature. This substantial heterogeneity is likely to be due to variations in the experimental trial duration, the broiler breeds used for treatments, the inclusion levels of seaweed, and environmental factors (Oretomiloye and Adewole, 2024). The differences in how *A. nodosum* affects broiler growth might be because studies used it in different ways. Several researchers used whole seaweed meal, while other researchers used special extracts with more concentrated nutrients. The amount of seaweed added to the feed and the experimental duration to broilers that were experimented with the seaweed di*et al*so varied. Plus, different breeds of broilers might not respond the same way to the supplement. Even things like temperature, housing, and overall health conditions could have played a role in the mixed results (Borzouie *et al*., 2020; Archer, 2023; Oretomiloye and Adewole, 2024).

The antimicrobial and probiotic capabilities make *A. nodosum* a great functionala dditive to aid gut health and performance (Okolie *et al*., 2019; Venardou *et al*., 2021).

The polysaccharides in *A. nodosum*, like fucoidan and laminarin, sup-

Table 1. Overview of the studies analyzed, including details on the author, broiler breed, year of publication, *Ascophyllum nodosum* supplementation level, age at supplementation, and sample sizes for control and treatment groups.

No.	Author	Broiler Breed	Amount of *A. nodosum*	Age	Control Sample size	Treatment Sample size
1	Bonifait *et al*. (2022)	Ross	0.20%	14, 21, 35	30	30
2	Kwak *et al*. (2024)	Ross 308	(1250, 2500, 5000) mg/kg	7, 14, 21, 28, 35	60	60
3	Akinyemi and Adewole (2022)	Ross 308	1 mL, 2mL	7, 14, 21, 28	84	84
4	Archer (2023)	Cobb 500	0.5g/Kg	42	120	120

port beneficial gut bacteria while reducing harmful ones, leading to better digestion and feed efficiency (Ummat *et al*., 2024). Additionally, the antioxidant and anti-inflammatory properties, assist to reduce oxidative stress in broilers, keeping them healthier and more productive (Dutot *et al*., 2012; Wang *et al*., 2022).

It also improves development of villi and their columnar epithelial lining and absorptive surface area. Especially in ileum sections that leads to increased gut health and better nutrient utilization. Followed by jejunum and then duodenum segments are the major absorptive regions of the digestive tract (El-naga *et al*., 2018). The development of villi is in tune with the increase in the number of goblet cells that produce mucin and directly work to balance out the intestinal microbiome and facilitate nutrient transport (Saragih *et al*., 2024).

Fucoidan exhibits multiple bioactivities, including immunostimulant, antiviral, and gastric protective effects, primarily due to its L-fructose compounds and sulphate esters (Nururrozi *et al*., 2018). Beyond these roles, fucoidan supplementation significantly reduces triglycerides and very-low-density lipoprotein cholesterol (VLDL-c) and effectively lowers low-density lipoprotein cholesterol (LDL-c) by regulating the expression of key enzymes involved in cholesterol and triglyceride synthesis (e.g., HMG-CoA reductase, acetyl-CoA carboxylase, and fatty acid synthase) in the liver through modulation of sterol regulatory element-binding proteins (SREBP)-2 (Park *et al*., 2016; Shokaiyan *et al*., 2019). These lipid-modulating and immunoregulatory effects are expected to improve nutrient utilization, enhance growth performance, and support better meat quality, making fucoidan a promising natural feed additive for sustainable broiler production.

High content of Alginate on *A. nodosum* also have contributes in lipid metabolism, gut health and decrease fat deposition that will improve growth performance in broiler chickens (Kwak *et al*., 2024). The high short-chain fatty acid production of bacteria in alginate will regulate the balance between fatty acid synthesis and oxidation, which will reduce excess fat deposition (Khatibjoo *et al*., 2018).

The high calculated Fail-safe N value shows the dependability and reliability of *A. nodosum* supplementation and indicates hypothetical 8,488 studies with null effect would be required to cause such an effect to overturn the observed means difference to be non-significant. In depth future studies are needed to explore the factors like dosage-dependent effects, processing methods, supplementation duration, environmental effect and breed-specific response. The interaction of *A. nodosum* to other dietary components also needs to be studied to improve its effectiveness in terms of gut health, feed efficiency, performance, and immune regulation (Azizi *et al*., 2021; Balasubramanian *et al*., 2021; Stokvis *et al*., 2021). Supplementation of seaweeds in diets suggest increased serum concentration of IgA antibody and IgM antibody may improve antibody production for immune system in broiler (Choi *et al*., 2014).

The findings of the current research further illustrate the multiple benefits of supplementing *Ascophyllum nodosum*, specifically because it is able for enhancing feed efficiency and broiler health through the application of biologically active compounds including polyphenols, laminarins, and fucoidans. These molecules appear to possess a role in regulating the gut microbiome regarding a more favourable microbial population in as well as promoting gut structure by elevating villus height and goblet cell growth (Reilly *et al*., 2008) Improved barrier function in the gut and this microbial transition might function in combination to minimize the probability of pathogenic colonization and promote nutritional absorption (Archer, 2023). The industrial level poultry production relies on efficient feed conversion ratio for sustainable and economic output and performance.

Ascophyllum nodosum is a functional alternative to AGPs and had implications for maintaining immunity and sustainable probiotic potential that influence broiler physiology (Michalak and Chojnacka, 2015). This ability is under the influence of its bio-active compounds that influence its role as an organic alternative to growth promoter and probiotics while also influencing lipid metabolism, lowered fat deposition, and serum profiling (Bonos *et al*., 2017). It's adaptability to varying production systems, protocols under different supplementation techniques, dosage dependent effects, long-term effectiveness, etc needs to be optimized for getting even large spectrum of benefits as multifunctional feed addictive (González-Meza *et al*., 2023).

Conclusion

Ascophyllum nodosum is persistent as an organic alternative of antibiotic growth promoters as broiler feed additive. The effectiveness is multi-faced with effects on body weight, gut development, immunity, and nutrient absorption, etc. Future studies should opt for dose-dependent, breed specific responses, dietary interaction with other components, and long-term effectiveness exploration.

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Conflict of interest

The authors have no conflict of interest to declare.

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