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Potential of *Sargassum* sp. in broiler chicken feed

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Abstract:
This study investigated the impact of the diet of broiler chickens 10% *Sargassum* sp. on their productive performance, gut health, and immune status.
The study was conducted in Maracay, Venezuela, and involved 264 Ross broilers distributed between two treatments (control and 10% *Sargassum* sp.) over three phases (Pre-starter, Starter, and Finisher). A one-way Analysis of Variance design was used, with three replicates of 44 birds.
The inclusion of *Sargassum* sp. did not significantly affect the final body weight ($p > 0.05$) (2759.34 vs. 2743.88 g for the control). However, the *Sargassum* sp. diet demonstrated two noteworthy benefits: it drastically improved the feed conversion ratio in all the phases (e.g., 1.07 vs. 1.53 in the Finisher) and considerably reduced mortality in the Pre-starter phase (6.82 vs. 20.25% for the control). The blood analysis demonstrated a positive hypocholesterolemic effect, with the *Sargassum* sp. treatment normalizing cholesterol levels and potentially reducing total lipids. However, the drinking water analysis revealed some quality issues (no residual chlorine, high nitrate levels), suggesting a high-stress environment and its possible influence on the overall health and performance results.
The inclusion of 10% *Sargassum* sp. in the broiler diet improved feed efficiency and early viability in broilers, although its growth-promoting effects may be limited by antinutritional factors (high ash) at this inclusion level.

Keywords: *Sargassum* sp., broilers, productivity, hematology, blood biochemistry, macroalgae, water

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INTRODUCTION

The global poultry industry faces a constant challenge in balancing the quality and cost of feed rations, which typically account for 60 to 70% of total operating expenses [1]. These formulations are dominated by traditional ingredients, primarily soybean meal and corn, as well as fishmeal. However, reliance on these products makes farmers vulnerable to price volatility and competition for resources on the global market. Furthermore, there is growing concern about the sustainability of these ingredients, linked to deforestation (soybeans) and overfishing (fishmeal).

At the same time, the poultry industry is undergoing a health transformation. The ban on, and growing public concern about, the use of antibiotic growth promoters in animal feed to increase bacterial resistance have created an urgent need for alternatives. This has spurred research into functional additives (eubiotics) that not only provide nutrients but also actively promote gut health and immunity in poultry. In this context, marine resources, specifically macroalgae, have emerged as a promising and sustainable alternative [1–4].

Macroalgae as a sustainable functional resource. Macroalgae, commonly known as seaweed, are a naturally abundant biomass. They are taxonomically classified into *Phaeophyceae* (brown), *Chlorophyceae* (green), and *Rhodophyceae* (red) [1]. The genus *Sargassum* (brown algae) is particularly interesting. These algae are rich in protein, minerals, vitamins, polysaccharides, and polyphenols [3]. The use of locally available natural resources such as macroalgae contributes significantly to food security and the sustainability of production systems [2]. In addition to their nutritional potential, macroalgae play a critical role in carbon dioxide capture and nutrient cycling in the marine ecosystem.

Brown seaweed and its derivatives are used as structural modifiers, antioxidants, preservatives, moisture-retaining agents, and sources of vitamins and minerals in the development of functional and preventive food products. They are also used as ingredients in meat, dairy, bakery and flour products, as well as in food additives and beverages, to provide potential health benefits and essential nutrients. Studies have proven the functional effectiveness of food products containing brown seaweed and its derivatives. The incorporation of seaweed components into functional foods could contribute to global food security [5].

The species of the genus *Sargassum*, which inhabit a wide range of habitats, can form large floating mats adrift in the open ocean. The massive recurrence of *Sargassum* in the Atlantic has generated a significant environmental and socioeconomic challenge. This challenge spurs efforts to transform this excessive biomass into an opportunity for various sectors, including animal feed. These algae utilize carbon dioxide and other nutrients, such as nitrogen and phosphorus, for their growth. Furthermore, they possess the capacity to absorb various pollutants from the aquatic environment.

Nutritional and biochemical profile of *Sargassum* sp. Seaweed is a complex and concentrated source of crucial nutrients, including proteins, minerals, vitamins, and carbohydrates [1]. Chemical analysis reveals that the crude protein content in seaweed can vary widely (from 9.07 to 63.63%), suggesting that it can partially replace imported protein sources in poultry feed [6].

A comparative analysis of the nutritional composition of different macroalgae has revealed specific characteristics for *Sargassum*. For example, *Sargassum wightii* Greville ex J. Agardh has a comparatively higher content of crude fiber, ether extract, acid-insoluble ash, and calcium, compared to *Gracilaria corticata* (J. Agardh) J. Agardh, 1852 and *Ulva lactuca* Linnaeus, 1753. In contrast, species such as *G. corticata* tend to have a higher content of crude protein and gross energy [7].

Furthermore, *Sargassum* species are notably rich in beta-carotene and various vitamins. Supplementing the base feed with *Sargassum* powder (at levels of 1 to 4%) has been shown to provide a greater amount of essential amino acids, long-chain fatty acids, and minerals necessary for poultry growth, compared to the diet without supplementation [8]. The lipid profile of algae includes fatty acid derivatives, terpenoids, and aliphatic hydrocarbons, many of which have a functional impact on animal physiology [7].

Functional effects and modulation of health. Scientific interest in applying biotechnology to nutrition focuses on the potential of macroalgae to act as nutraceuticals or functional additives. This functionality stems from the presence of bioactive molecules that exhibit antioxidant, anti-inflammatory, antifungal, and antimicrobial properties. These bioactive components possess remarkable medicinal properties, including anti-inflammatory, cholesterol-lowering, and hepatoprotective effects [7].

The dietary inclusion of brown algae has been shown to improve the health and physiological state of broilers, namely:

– immune response. Supplementation with algae such as *Sargassum* sp., *Spirulina* sp., or *Gracilaria* sp. can positively modulate the immune status of broiler chickens [9]. Specifically, supplementation with 0.13% of brown algae (*S. wightii*) has been shown to significantly improve cell-mediated immune response and increase the weight of lymphoid organs (thymus and spleen), the key elements in the body defense [3]. A study with *Sargassum siliquastrum* (Mertens ex Turner) C. Agardh 1820 in Japanese quail also reported a significant improvement in immune response [10];

– lipid metabolism (a positive cholesterol-lowering effect). In specific trials, dietary supplementation with *Sargassum muticum* extract has been shown to significantly reduce total cholesterol in broiler chickens [11, 12].

Zootechnical challenges and antinutritional factors. Despite the clear immunological and metabolic potential of macroalgae, their incorporation into monogastric diets presents significant challenges, mainly due to the presence of antinutritional factors. The main of such factors in the brown algae *Sargassum* sp. is their high alginate content [13]. Alginates are polysaccharides that can increase the viscosity of intestinal contents, hindering the digestion and absorption of nutrients and binding to them, which can potentially reduce feed efficiency.

This challenge highlights the need to optimize the inclusion and processing of macroalgae to ensure maximum nutrient assimilation. For example, processing methods were investigated to reduce the alginate content in *Sargassum binderi* Sonder ex J. Agardh, 1848 for use in laying hen feed [13]. Similarly, other authors reduced the salt content in *Sargassum crassifolium* J. Agardh, 1848 meal by immersion, achieving an inclusion rate of up to 18% without adverse effects on internal organs [14].

Environmental and food safety risk. A crucial aspect of food traceability and safety is the ability of algae to absorb and concentrate contaminants from the aquatic environment. The main concern is the bioaccumulation of heavy metals (such as arsenic) and, to a lesser extent, organic contaminants. Furthermore, the presence of naturally occurring radioactive elements such as lead and polonium has been reported in algae [2]. Although *Sargassum* has been considered as antinutrient-free in some contexts, the risk of heavy metal contamination is a critical consideration that requires strict quality control and monitoring of the harvesting source. The occurrence of harmful algal blooms also poses a risk to the safety of using algae in animal feed [2].

Evidence of productive performance. Scientific literature presents a mixed picture of using algae at different inclusion levels. A systematic review and meta-analysis confirmed the strong interest in using seaweed as a functional ingredient in poultry feed [15]. Regarding production outcomes, there is conflicting evidence, although the immunological and lipid metabolism benefits are well documented. For example, in a trial with broiler chickens, supplementation with 0.13% of brown algae (*S. wightii*) resulted in greater weight gain and a better feed conversion ratio [3]. In another study, *Sargassum*'s growth-promoting ability reached its maximum effect at 2% inclusion, achieving a significantly greater weight gain compared to the control group [8]. The inclusion of up to 18% *S. crassifolium* or up to 2% (20 g/kg) algae mixtures, respectively, did not significantly affect the chickens' growth performance (daily weight gain and feed conversion ratio) or live weight, although the supplementation had a positive effect on their gastrointestinal ecology [14, 16].

Therefore, we aimed to evaluate the inclusion of 10% *Sargassum* sp. in the formulation of a balanced feed for broiler chickens, focusing on productive variables and blood parameters.

STUDY OBJECTS AND METHODS

Location and environmental conditions. The study was conducted at the Nicolino Ierrobueno agricultural production unit (Maracay, Aragua State, Venezuela). The average temperature at the study site was 30.3°C and the humidity was 57.5%.

Experimental design and bird management. A one-way Analysis of Variance (ANOVA) design was used, with two treatments, each consisting of 132 one-day-old Ross chicks divided into three replicates of 44 broilers, across three stages: Pre-starter (1–10 days), Starter (11–22 days), and Finisher (23–42 days). The chicks were raised in pens measuring 4.84 m² with rice husk bedding, as shown in Fig. 1. They were provided with water and feed ad libitum. During the Pre-starter stage, the broilers had heat lamps all day and in the Starter phase, only at night.

Dietary treatments. The control group received commercial feed, and the experimental group received commercial feed with 10% of the macroalgae *Sargassum* sp.

Feed and water analysis. The bromatological analysis of the raw materials and feed was carried out according to the official methods of analysis developed by the Association of Analytical Communities[1]. The quality of drinking water was evaluated in accordance with ISO 5667.

Productive variables and data collection. Weighing was performed on an HZ50002B CGoldenwall balance. Fifteen birds per treatment were weighed at various stages, namely on days 1, 4, 7, and 10 (Pre-starter); 14, 21, and 22 (Starter); and 28, 35, and 42 (Finisher). The feed offered but not consumed was weighed daily. We evaluated: initial body weight, final body weight, daily feed intake, daily weight gain, increased weight gain, feed conversion ratio, mortality, complete blood count, and blood biochemistry. The equations were as follows:

$$\mathrm{DFI} = \frac{F_o - F_c}{\text{Total number of animals}} \quad (1)$$

where DFI is the daily feed intake, g; F_o is the feed offered, g; and F_c is the feed not consumed, g.

$$\mathrm{IBW} = \mathrm{FBW} - \mathrm{IBW} \quad (2)$$

[1] AOAC. Official methods of analysis of the association of official analytical chemists. 20th ed. Washington: AOAC Inc., 2016.

a

b

Figure 1 Experimental facilities: a – experimental pens; b – pre-starter phase

where IWG is the increased weight gain, g; IBW is the initial body weight, g; and FBW is the final body weight, g.

$$\mathrm{FCR} = \frac{Q_f}{W_g} \quad (3)$$

where FCR is the feed conversion ratio; Q_f is the quantity of feed consumed during a period, g; and W_g is the weight gain during the same period, g.

$$\%\ \text{Mortality} = \frac{\text{Total deaths} \times 100}{\text{Total population}} \quad (4)$$

Blood and biomarkers. Chicken blood was drawn by cardiac puncture. On day 1, a pooled sample was taken from the broiler chicken without any dietary intervention as a baseline value. From day 7 onward, the blood profile was monitored weekly (Fig. 2), with processing carried out according to ISO 15189:2022 (the quality of clinical laboratories).

Statistical analysis. The data were analyzed using the Statistical Product and Service Solutions (SPSS) software, IBM SPSS version 21. The following model was used to describe the diets' effects on the productive traits:

$$Yij = \mu + Ti + eij \quad (5)$$

where μ is the overall mean; *Ti* is the treatment effect (*i* = control, *Sargassum* sp.); and *eij* is the experimental error.

Mortality data, being binomial, were analyzed separately using the Chi-square (χ^2) test to determine the significance of differences between the treatments. The differences were considered statistically significant at $p < 0.05$.

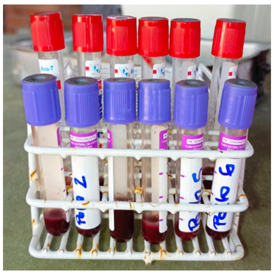

Figure 2 Blood samples

Table 1 Proximate composition of *Sargassum* sp., %

Parameter	*Sargassum* sp.
Moisture	14.17
Protein	6.99
Fat	0.42
Ash	32.13
Fiber	10.60
Calcium	4.66
Phosphorus	0.09

Table 2 Proximate composition of the diets at various stages, %

Parameter	Pre-Starter		Starter		Finisher	
	Control	*Sargassum* sp.	Control	*Sargassum* sp.	Control	*Sargassum* sp.
Moisture	9.50	10.87	9.35	10.81	11.42	11.51
Protein	19.36	20.48	19.38	20.10	19.44	18.98
Fat	7.88	7.72	10.27	10.17	9.56	10.23
Ash	9.36	8.94	6.15	8.21	5.46	7.44
Fiber	2.42	2.90	2.27	2.89	2.68	2.87
Calcium	1.60	1.61	1.19	1.19	0.90	1.08
Phosphorus	0.68	0.65	0.60	0.60	0.62	0.58

Ethical considerations. In compliance with the ethical standards, we followed the institutional and national guidelines for the care and use of laboratory animals under the directives of the Bioethics Committee for Animal Research of the Venezuelan Institute for Scientific Research[2].

RESULTS AND DISCUSSION

Proximate composition of *Sargassum* sp. Table 1 shows the proximate analysis of the brown macroalgae *Sargassum* sp. This alga has high mineral, fiber, and protein contents. Its significant nutritional value makes it an important raw material for feed formulations in all three growth phases evaluated in chickens. Various authors obtained similar bromatological results, suggesting that this alga can partially substitute imported protein and other nutrient sources used for poultry feed [2, 12, 14].

Proximate composition of the diets. In the proximate composition profiles of the diets used (Table 2), slight variations were observed between the control and *Sargassum* sp. treatments for parameters such as moisture, protein, fat, ash, fiber, calcium, and phosphorus at different stages (Pre-starter, Starter, Finisher). These diets were isocaloric and isoprotein, consistent with the literature [3, 4, 9]. The protein content in the *Sargassum* sp. diet was slightly higher in the Pre-starter phase (20.48%) compared to the control (19.36%). This difference, although small, could contribute to better early development, considering that the seaweed is a complex source of crucial nutrients, including proteins [7–9]. However, at the Finisher stage, the protein content in the *Sargassum* sp. diet was slightly lower (18.98%) compared to the control (19.44%). These variations in protein could influence the daily weight gain and feed conversion efficiency. As can be seen in Fig. 3, the *Sargassum* sp. treatment showed a lower feed conversion ratio in the Pre-starter, Starter, and Finisher stages, suggesting better feed utilization efficiency.

Regarding fiber, the *Sargassum* sp. diet exhibited slightly higher values at all stages. This increase in fiber, although modest, could have implications for the intestinal health of the birds. Dietary fiber has been shown to influence intestinal morphology and cecal microbiota, which are essential for nutrient digestion and absorption [17, 18]. The presence of fiber in seaweed can contribute to a healthier intestinal environment, which in turn optimizes the overall performance of chickens.

The fat content in the *Sargassum* sp. diet was lower than in the control in the Pre-Starter (7.72 vs. 7.88) and Starter (10.17 vs. 10.27) stages. However, in the Finisher stage, the supplemented diet had a higher fat content than the control (10.23 vs. 9.56).

Regarding minerals, differences were observed in ash, calcium, and phosphorus contents. Ash, which represents the total mineral content, was generally higher in the *Sargassum* sp. diet in the Starter (8.21 vs. 6.15%) and Finisher (7.44 vs. 5.46%) stages. This is consistent with the studies highlighting seaweed as a rich source of minerals [7–9]. The calcium content in the *Sargassum* sp. diet was slightly higher in the Finisher stage (1.08 vs. 0.90%). The phosphorus content in the supplemented diet was lower than, or equal to, that in the control. The availability of these minerals is crucial for bone development and other physiological functions in broiler chickens.

Drinking water quality. The analysis of the quality of the drinking water used in the study (Table 3)

[2] Bioethics Committee for Animal Research of the Venezuelan Institute for Scientific Research. COBIANIM 2025-02; May 13, 2025.

Table 3 Drinking water quality

Parameter	Result	Regulated value
Residual free chlorine, mg/L Cl*	0	0.3–1.0 (provisionally accepted up to 3.0)
Turbidity, NTU	1.5	5
Apparent color, Pt/Co	5	15
pH*	6.322	6.5–8.5
Total iron, mg/L Fe	0.1	0.3 (provisionally accepted up to 1.0)
Manganese, mg/L Mn	0	0.5
Nitrite, mg/L NO_2	0.02	(Nitrite + Nitrate as N) < 10 mg/L
Nitrate, mg/L NO_3*	34.53	(Nitrite + Nitrate as N) < 10 mg/L (approx. 7.85 mg/L N from nitrate)
Chloride, mg/L Cl	17.85	300
Sulfate, mg/L SO_4	23.53	500
Total dissolved solids, mg/L	247.04	1,000

* – values found out of range

revealed that some values fell outside the regulated range, which is a critical factor to consider in poultry production.

Specifically, the free residual chlorine was 0 mg/L Cl, which is below the accepted range of 0.3–1.0 mg/L Cl. The absence of residual chlorine can compromise the microbiological quality of the water, since chlorine is a fundamental disinfectant for controlling the proliferation of microorganisms in poultry farm drinking water systems [19]. Poor microbiological water quality can increase the microbial load in the gastrointestinal tract of chickens, affecting their health and performance [17, 18]. The water pH (6.32) was also found to be outside the regulated range of 6.5–8.5. A slightly acidic pH, such as the one observed, can influence the palatability of the water and, consequently, the birds' water intake. Moreover, the water's pH can affect the efficacy of certain additives and overall intestinal health. For example, Mohamed *et al.* [20] demonstrated that ionized water with a slightly alkaline pH can improve the productive performance and physiological status of broiler chickens. Although we did not use ionized water, the deviation from the optimal pH could have influenced the results.

Another parameter outside the acceptable range was nitrate (34.53 mg/L NO_3), exceeding the reference value for the sum of nitrite + nitrate as N (< 10 mg/L). Elevated nitrate levels in drinking water can be harmful to avian health, affecting their performance and overall well-being. Water quality is a key component in maintaining the health, well-being, and productive performance of birds [20].

Productive parameters. Figure 3 illustrates the average body weight of the chickens over time. While a similar growth pattern was observed in both treatments, the *Sargassum* sp. treatment showed a slightly higher weight in the final stages of the study. The statistical analysis of daily weight gain in the broilers showed no

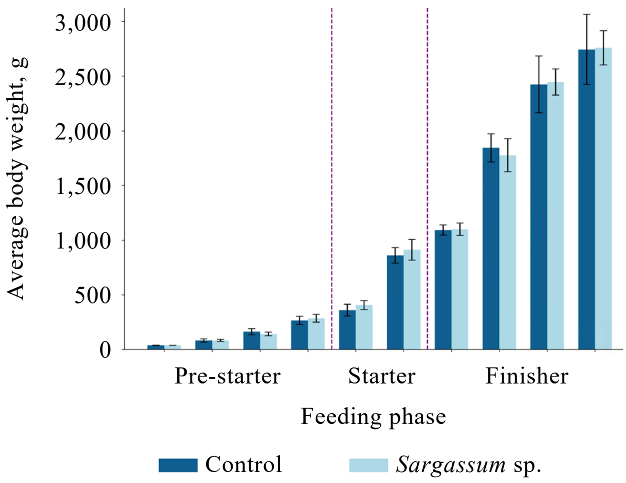

Figure 3 Changes in average body weight of broiler chickens by treatment

significant differences ($p < 0.05$) between the control and *Sargassum* sp. treatments.

The improved weight in the experimental group is consistent with various studies that have reported *Sargassum* sp.'s positive effects on the nutritional value of feed, productive parameters, and the health of the birds [2, 3, 6, 7, 9, 11, 12].

Table 4 demonstrates the productive parameters evaluated at different stages of the study. In the Pre-starter phase, the *Sargassum* sp. treatment showed slightly higher final body weight (285.40 g) and increased weight gain (246.82 g) compared to the Control (265.80 and 227.16 g, respectively). This initial increase in yield suggests an early beneficial effect of the macroalgae. The daily feed intake was also notably higher in the *Sargassum* sp. treatment at this stage (43.41 vs. 25.11 g). Combined with greater weight gain, this translates into better efficiency. These results are consistent with those of Kumar [8], who conducted dietary supplementation with *Sargassum wightii* Greville ex J. Agardh. and observed improved feed intake and body weight gain in poultry. A particularly relevant finding in the Pre-starter phase was that the feed conversion ratio was significantly lower in the *Sargassum* sp. treatment (0.35 vs. 0.75). This indicates that the birds use feed more efficiently for growth, which is a crucial factor from an economic perspective in poultry production. These findings are consistent with those in previous studies [11, 12, 14, 16, 21], which reported a marked improvement in the feed conversion ratio.

Mortality was lower in the *Sargassum* sp. group in the Starter phase but higher in the Finisher phase, compared to the Control (3.03 vs. 6.06% and 5.30 vs. 0.00%, respectively). The Pre-starter phase demonstrated the significant decrease in mortality in the *Sargassum* sp. treatment (6.82%) compared to the Control (20.45%). This reduction in mortality is an important indicator of improved overall health and well-being of the broilers supplemented with *Sargassum* sp., especially during the most vulnerable phases of the chicks' life. Algae can be

Table 4 Productive parameters of broiler chickens at various stages

Parameter treatment	Pre-starter		Starter		Finisher	
	Control	*Sargassum* sp.	Control	*Sargassum* sp.	Control	*Sargassum* sp.
Initial body weight, g	38.64	38.58	265.80	285.40	1092.07	1099.27
Final body weight, g	265.80	285.40	1092.07	1099.27	2743.88	2759.34
Daily feed intake, g	25.11	43.41	98.95	73.75	214.90	214.68
Increased weight gain, g	227.16	246.82	826.27	813.87	1651.81	1660.08
Feed conversion ratio	0.75	0.35	0.99	0.77	1.53	1.07
Mortality, %	20.45	6.82	6.06	3.03	0.00	5.30

Table 5 Complete blood count of the control chickens

Parameter	Reference value	Days					
		7	14	21	28	35	42
Hemoglobin, g/dL	8.00–18.00	7.3*	11.6	10.4	9.7	8.0	10.4
Leucocytes, cell/μL or mm^3	4,000–40,000	29,751	90,871**	59,583**	21,450	31,949	45,117**
Segmented, %	20–50	51**	35	46	50	55**	46
Lymphocytes, %	45–75	47	62	50	46	42*	52
Eosinophils, %	0–2	1	1	2	2	1	1
Monocytes, %	2–10	1*	2	2	2	2	1*
Platelets, cells/μL or mm^3	15,000–35,000	2,000*	3,000*	3,000*	1,000*	2,000*	10,000*

* – below reference value; ** – above reference value. Values not determined

used as an alternative to antibiotics in broiler chickens to improve productive performance and reduce harmful pathogens in the gut [3–9]. The authors reported a positive effect of brown algae dietary supplementation on broiler performance and health. In another study, supplementation of broiler feed with algae such as *Sargassum* sp. improved the birds' cellular and humoral immune status, as well as their healthy intestinal microflora [2].

In the Starter and Finisher phases, the productive parameters such as the final body weight, daily feed intake, and increased weight gain were relatively similar between the two treatments. However, the feed conversion ratio in the *Sargassum* sp. group remained consistently lower than that of the Control group in the Starter phase (0.77 vs. 0.99) and in the Finisher phase (1.07 vs. 1.53). This reinforces the idea that the inclusion of *Sargassum* sp. in the diet improves feed efficiency throughout the entire production cycle, even though the differences in weight gain are not as pronounced in the later phases.

These findings align with the literature reporting positive effects of various seaweed species on broiler performance. For example, supplementation with *S. wightii* has been shown to increase weight gain and improve the feed conversion ratio [8]. Similarly, the inclusion of *Sargassum siliquastrum* (Mertens ex Turner) C. Agardh 1820 in the diet of Japanese quail has positively influenced its body weight [10]. The ability of algae to improve small intestine morphology and nutrient absorption, as observed with *Chaetomorpha linum* (O.F. Müller) Kützing, 1845 [21], resulted in improved weight gain, body weight, and feed conversion ratio. Furthermore, the use of brown seaweed meal such as *Sargassum crassifolium* J. Agardh, 1848 has been shown to positively affect growth performance, even at inclusion levels of 18% [14].

Complete blood count. The complete blood count results allowed for the evaluation of health and physiological status for both treatments throughout the study. In the Control group, hemoglobin levels were below the reference range on day 7 (7.3 g/dL), with leukocytes and platelets frequently above or below the reference values throughout the study (Table 5). Segmented neutrophils and lymphocytes also showed fluctuations outside the normal ranges on some days.

According to Table 6, hemoglobin in the *Sargassum* sp. group was also below the normal range on day 7 (6.5 g/dL). Leukocytes were above the reference range for almost the entire study and platelets were below the reference range throughout the trial. Segmented neutrophils and lymphocytes also showed variations relative to the reference values.

However, a study that evaluated the effect of dietary supplementation with *S. wightii* and *Gracilaria corticata* (J. Agardh) J. Agardh, 1852 on the blood profiles of TANUVAS Aseel chickens found these parameters within the reference ranges, namely hemoglobin, segmented neutrophils, lymphocytes, eosinophils, monocytes, and platelets [6]. Another study revealed that the addition of *Sargassum* sp., *Spirulina* sp., and *Gracilaria* sp. significantly reduced leukocytes [2]. The authors also reported that the *Sargassum* sp. treatment showed the same levels of heterophils and lymphocytes as in the control group, as well as the highest levels of monocytes among the treatments.

Blood biochemistry. Table 7 shows the blood biochemistry parameters of the control broilers. As can be seen, urea, alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, and total protein showed out-of-range values (mostly above) throughout the study. Blood glucose, creatinine, and calcium

Table 6 Complete blood count of *Sargassum* sp.-treated chickens

Parameter	Reference value	Days					
		7	14	21	28	35	42
Hemoglobin, g/dL	8.00–18.00	6.5*	9.1	9.4	9.3	8.9	9.5
Leucocytes, cell/μL or mm^3	4,000–40,000	53,788**	83,380**	64,030**	24,465	47,243**	29,836
Segmented, %	20–50	60**	61**	47	49	46	46
Lymphocytes, %	45–75	35*	36*	50	47	51	51
Eosinophils, %	0–2	2	1	1	2	2	2
Monocytes, %	2–10	3	2	2	2	1*	1*
Platelets, cells/μL or mm^3	15,000–35,000	–	2,000*	2,000*	1,000*	1,000*	1,000*

* – below reference value; ** – above reference value. Values not determined

Table 7 Blood biochemistry of the control chickens

Parameter	Reference value	Days						
		1	7	14	21	28	35	42
Blood glucose, mg/dL	200–370	244	248	321	225	195*	248	219
Urea, mg/dL	2.50–5.00	17.50**	5.70**	1.70*	3.90	11.30**	0.36*	8.10**
Creatinine, mg/dL	0.17–0.42	2.24**	0.42	0.29	0.38	0.14*	0.18	0.24
ALT, UI/L or U/L	20–50	252**	10*	138**	157**	150**	260**	321**
AST, UI/L or U/L	25–275	287**	8*	302**	169	165	270	313**
Total bilirubin, mg/dL	0.006–0.120	0.28**	0.78**	0.15**	0.69**	0.77**	0.46**	0.47**
Total protein, mg/dL	2.50–4.50	1.82*	2.59	2.06*	2.24*	2.83	2.43*	3.17
Blood calcium, mg/dL	8.00–11.00	9.96	9.47	10.33	10.59	8.07	11.97**	9.07
Cholesterol, mg/dL	87–192	249**	231**	167	142	174	141	89
Triglycerides, mg/dL	31–166	51	168**	31	102	124	67	14*

ALT – alanine aminotransferase; AST – aspartate aminotransferase; * – below reference value; ** – above reference value

Table 8 Blood biochemistry of *Sargassum* sp.-treated chickens

Parameter	Reference value	Days						
		1	7	14	21	28	35	42
Blood glucose, mg/dL	200–370	244	127*	129*	381**	262	254	381**
Urea, mg/dL	2.50–5.00	17.50**	2.6	7.70**	2.30*	12.10**	10.50**	6.80**
Creatinine, mg/dL	0.17–0.42	2.24**	0.02*	0.02*	0.40	0.21	0.45**	0.19
ALT, UI/L or U/L	20–50	252**	5*	25	125**	156**	241**	251**
AST, UI/L or U/L	25–275	287**	3*	274	175	187	222	254
Total bilirubin, mg/dL	0.006–0.12	0.28**	0.61**	2.01**	0.53**	1.76**	0.36**	0.99**
Total protein, g/dL	2.50–4.50	1.82*	0.8*	4.01	3.09	2.91	2.6	2.68
Blood calcium, mg/dL	8.00–11.00	9.96	0.99*	10.25	12.84**	10.32	10.69	10.49
Cholesterol, mg/dL	87–192	249**	211**	153	153	175	131	99
Triglycerides, mg/dL	31–166	51	175**	76	225**	199**	63	58

ALT – alanine aminotransferase; AST – aspartate aminotransferase; * – below reference value; ** – above reference value

levels fluctuated, with some values falling outside the reference ranges at several time points. Cholesterol and triglycerides showed mostly normal values, with some values falling outside the reference range.

The blood biochemistry parameters of the *Sargassum* sp.-treated broilers are presented in Table 8. As can be seen, blood glucose, urea, creatinine, ALT, and total bilirubin levels were outside the normal range, predominantly above the reference values. AST and total protein showed some deviations from the normal ranges. These results were similar to those reported in a study evaluating the supplementation with *S. wightii* and *G. corticata* in TANUVAS Aseel chickens. In particular, the authors recorded elevated uric acid and creatinine levels in all the treatments and a highly significant reduction in AST [6].

The heterophil, lymphocyte, eosinophil, and thrombocyte counts, as well as the heterophil-to-lymphocyte ratio, serum sodium, and uric acid are significant markers of physiological stress in broiler chickens subjected to crowding or feed deprivation stress [22]. It is noteworthy that blood calcium was below the reference range on day 7 (0.99 mg/dL) and above it on day 21 (12.84 mg/dL). These extreme fluctuations in calcium levels cause concern, as calcium is vital for bone health, nerve function, and muscle function in birds. Although seaweed is rich in minerals, including calcium [7–9], the dynamics of its absorption and metabolism in the presence of *Sargassum* sp. could be complex, requiring further investigation.

Regarding lipids, cholesterol in the *Sargassum* sp. treatment was above the normal range on days 1 and 7, but then normalized. Triglycerides also showed elevated values on days 7, 21, and 28, and although peaks were observed, the overall trend toward normalization in the final stages could be a positive effect. The hypocholesterolemic effect of *Sargassum* sp. might be due to its active ingredients, such as saponins, hemicelluloses, mucilages, tannins, and pectins, which help reduce low-density lipoprotein cholesterol in the blood. In another study, the total lipid profile showed a significant reduction in total cholesterol in broiler chickens exposed to dietary supplementation with *Sargassum muticum* (Yendo) Fensholt, 1955 extract [12]. The inclusion of *S. muticum* and *Pulicaria undulata* (L.) C.A. Mey. extracts was also found to significantly decrease total plasma lipids and, at the same time, increase high-density lipoprotein cholesterol levels in broiler chickens [11].

CONCLUSIONS

The inclusion of the macroalgae *Sargassum* sp. into broiler diets demonstrates its potential as a functional additive. The proximate analysis confirmed its richness in minerals, with 32.13% ash and 10.6% fiber, positioning it as a valuable ingredient for feed formulation.

Throughout the three growth phases, the inclusion of 10% *Sargassum* sp. had a notable effect on the productive parameters. While the final body weight was not significantly different ($p > 0.05$), the supplemented diet significantly improved the feed conversion ratio and notably reduced early mortality. The improved feed conversion ratio, particularly significant in the Pre-starter phase (0.35 vs. 0.75), indicates that the broilers used the feed more efficiently. Furthermore, the significant reduction in mortality (6.82% in the *Sargassum* sp. group vs. 20.45% in the Control group) suggests a positive effect of the alga's bioactive agents on the overall well-being of the chickens, as supported by the literature.

Despite these positive results, it is important to consider the impact of drinking water quality, since out-of-range values for residual free chlorine, pH, and nitrates could have influenced the performance and health parameters of the broilers in both treatments.

While fluctuations in hematological and blood biochemistry parameters were evident in both treatments, the *Sargassum* sp. diet showed a trend toward normalizing cholesterol levels in the final stages, consistent with the hypocholesterolemic effect reported in other studies. However, extreme calcium variations were observed in the *Sargassum* sp. treatment, which warrants further investigation to understand the dynamics of this mineral's absorption and metabolism.

Finally, our findings support the feasibility of using *Sargassum* sp. as a nutritional supplement in broiler chicken feed. Its benefits in feed conversion efficiency and the reduction of early mortality highlight its potential to improve the sustainability and profitability of poultry production. However, they also suggest areas for future research, such as optimizing the dosage and gaining a deeper understanding of its physiological impact.

CONTRIBUTION

L.C. Vivas: research concept, design, literature search, experimental studies, manuscript editing. A.D. Mendoza: manuscript preparation, data acquisition, experimental studies. M.J. Casado: definition of intellectual content, literature search, manuscript editing. N.C. Pérez: research design, data analysis, statistical analysis, manuscript review. M.F. Brazón: data analysis, statistical analysis, graphics. D.S. Coll: definition of intellectual content, literature search, manuscript editing. A.J. Quintero: research design, definition of intellectual content, experimental studies, manuscript editing.

CONFLICT OF INTEREST

The authors declare the absence of any conflict of interest.

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REFERENCES

1. Al-Khalaifah H, Al-Nasser AY. Evaluating the potential of *Marine algae* as sustainable ingredients in poultry feed. Agriculture. 2024;14(11):1889. https://doi.org/10.3390/agriculture14111889
2. Al-Khalaifah H, Uddin S. Assessment of *Sargassum* sp., *Spirulina* sp., and *Gracilaria* sp. as poultry feed supplements: Feasibility and environmental implications. Sustainability. 2022;14(14):8968. https://doi.org/10.3390/su14148968
3. Chavan V, Kulkarni R, Awandkar SP, Chavhan SG, Gaikwad NZ, *et al*. Effect of dietary supplementation of brown seaweed on performance of broiler chicken. Indian Journal of Animal Sciences. 2022;92(8):999–1005. https://doi.org/10.56093/ijans.v92i8.123132
4. Stokvis L, van Krimpen MM, Kwakkel RP, Bikker P. Evaluation of the nutritional value of seaweed products for broiler chickens' nutrition. Animal Feed Science and Technology. 2021;280:115061. https://doi.org/10.1016/j.anifeedsci.2021.115061

5. Alloyarova YuV, Kolotova DS, Derkach SR. Nutritional and therapeutic potential of functional components of brown seaweed: A review. Foods and Raw Materials. 2024;12(2):398–419. https://doi.org/10.21603/2308-4057-2024-2-616
6. Vijayalingam TA, Rajesh NV, Vairamuthu S, Boopathy Raja M, Sudeep Kumar NK. Effect of dietary supplementation of seaweeds on growth and blood profiles of TANUVAS Aseel chicken: Seaweed feed trails in poultry. Journal of the Hellenic Veterinary Medical Society. 2023;74(3):6085–6092. https://doi.org/10.12681/jhvms.30812
7. Vijayalingam TA, Rajesh NV. Nutritional and bioactive compounds of certain seaweeds: A livestock and poultry feed supplements. Russian Agricultural Sciences. 2023;49:223–228. https://doi.org/10.3103/S1068367423020155
8. Kumar A. Effect of *Sargassum* sp. *wightii* on growth, carcass and serum qualities of broiler chickens. Open Access Journal of Veterinary Science & Research. 2018;3(2):000156. https://doi.org/10.23880/oajvsr-16000156
9. Al-Khalaifah HS, Al-Nasser A, Surrayai T. Effects from dietary addition of *Sargassum* sp., *Spirulina* sp., or *Gracilaria* sp. powder on immune status in broiler chickens. Frontiers in Veterinary Science. 2022;9:928235. https://doi.org/10.3389/fvets.2022.928235
10. Abu Hafsa SH, Hassan AA. The effect of *Sargassum siliquastrum* supplementation on growth performance, cecal fermentation, intestine histomorphology, and immune response of Japanese quails. Animals. 2022;12(4):432. https://doi.org/10.3390/ani12040432
11. El-Fatah RAS, Abousekken MSM, Zaid AA, El-Tabaa MM, Ghazalah AA. Effect of dietary supplemention with *Sargassum muticum algae* and *Pulicaria undulate* (Rabol) on growth performance, blood parameters, immune response, manure characteristics and ammonia emissions of broilers. International Journal of Environmental Studies and Researches. 2024;3(1):28–56. https://doi.org/10.21608/ijesr.2024.346556
12. El-Fatah RAS, Abousekken MSM, Zaid AA, El-Tabaa MM, Ghazalah AA. Effect of different dietary levels of *Sargassum muticum* powder and/or extract on broilers performance and blood biochemistry. International Journal of Environmental Studies and Researches. 2023;2(4):120–138. https://doi.org/10.21608/ijesr.2023.346728
13. Dewi YL, Yuniza A, Nuraini, Sayuti K, Mahata ME. Processing of *Sargassum binderi* Seaweed for Supplementation in Poultry Diet. Journal of World's Poultry Research. 2023;13(1):103–111. https://doi.org/10.36380/jwpr.2023.11
14. Mahata ME, Rizal Y, Zurmiati, Reski S, Limbong IFS, *et al*. Impact of utilization of brown seaweed *Sargassum crassifolium* in broilers diet as a substitution of traditional feed ingredients. Journal of Animal Health and Production. 2023;11(4):404–409. https://doi.org/10.17582/journal.jahp/2023/11.4.404.409
15. Andri F, Dono ND, Sasongko H, Zuprizal Z. The effects of dietary seaweed inclusion on growth performance of broiler chickens: A systematic review and meta-analysis. F1000Research. 2020;9:1087. https://doi.org/10.12688/f1000research.25726.1
16. Mohammadigheisar M, Shouldice VL, Sands JS, Lepp D, Diarra MS, *et al*. Growth performance, breast yield, gastrointestinal ecology and plasma biochemical profile in broiler chickens fed multiple doses of a blend of red, brown and green seaweeds. British Poultry Science. 2020;61(5):590–598. https://doi.org/10.1080/00071668.2020.1774512
17. Meng W, Zou Q, Xiao Y, Ma W, Zhang J, *et al*. Growth performance and cecal microbiota of broiler chicks as affected by drinking water disinfection and/or herbal extract blend supplementation. Poultry Science. 2023;102(7):102707. https://doi.org/10.1016/j.psj.2023.102707
18. Meng W, Sui X, Xiao Y, Zou Q, Cui Y, *et al*. Regulating effects of chlorinated drinking water on cecal microbiota of broiler chicks. Poultry Science. 2023;102(12):103140. https://doi.org/10.1016/j.psj.2023.103140
19. Li Z, Liu C, Shao D, Tan C, Cao Y, *et al*. Low-concentration hypochlorous acid drinking water alleviates broiler gut microbial load while preserving overall growth performance. Toxics. 2025;13(1):48. https://doi.org/10.3390/toxics13010048
20. Mohamed A, Khalil M, Soliman F, El-Sabrout K. The effect of drinking ionized water on the productive performance, physiological status, and carcass characteristics of broiler chicks. Animals. 2025;15(2):229. https://doi.org/10.3390/ani15020229
21. Saragih HT, Fauziah IN, Saputri DA, Chasani AR. Dietary macroalgae *Chaetomorpha linum* supplementation improves morphology of small intestine and pectoral muscle, growth performance, and meat quality of broilers. Veterinary World. 2024;17(2):470–476. https://doi.org/10.14202/vetworld.2024.470-479
22. Nwaigwe C, Ihedioha J, Shoyinka S, Nwaigwe C. Evaluation of the hematological and clinical biochemical markers of stress in broiler chickens. Veterinary World. 2020;13(10):2294–2300. https://doi.org/10.14202/vetworld.2020.2294-2300

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