Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.111222

Performance, carcass quality and intestinal biometry of feed European quails with seaweed meal (*Sargassum* sp)

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Abstract

This work aims to evaluate, at different stages, the productive performance, carcass quality, and intestinal biometry of European quails (Coturnix coturnix Coturnix), consuming diets with increasing levels of seaweed bran (Sargassum sp). A total of 240 European quail chicks (Coturnix coturnix Coturnix) were distributed in a completely randomized design, with four levels of bran inclusion (0.0, 2.5, 5.0, and 7.5%), 6 replications with 10 birds in each experimental plot. In the period from 1 to 21 days, the feed intake of the control group was higher, with lower water consumption. In the period from 22 to 42 days, feed and water consumption increased with the inclusion of seaweed, but with a reduction in weight gain. In the total period, water consumption was higher at the level of 2.5 and 7.5%, with lower consumption in the control group, with a small reduction in slaughter and carcass weight with the inclusion of bran. There was no difference ($P > 0.05$) in carcass quality and intestinal biometry. We recommended the inclusion of up to 7.5% of sargassum meal in the diet of European quails at all stages, without compromising its productive performance, carcass quality, and intestinal biometry.

Keywords: macroalga; Coturnix coturnix Coturnix; alternative feed.

Practical Application: In the quail breed as a means of supplement replacing antibiotics.

1 Introduction

In poultry farming, "friendly additives" should be sought to replace the frequent use of vaccines, medicines, and antibiotics (Hafez & Attia, 2020). Therefore, the use of probiotics, prebiotics, herbal powders, and algae products in bird diets, which are interesting to improve growth and reproduction, as well as innate immunity that provides adequate protection to birds, has become popular as an alternative. to antibiotics around the world in recent years (Hafsa et al., 2019; Arif et al., 2022; Hafsa & Hassan, 2022).

In addition to what has been said, the use of alternative foods for quails aims to reduce production costs and the reuse of waste discarded in agro-industrial processes, which must be available in quantity and quality, have good levels of micro and macronutrients, maintain or improve the productive performance, meat and egg quality and poultry welfare (Brunelli et al., 2018; Ferreira et al., 2019; Xavier et al., 2020; Nnadi et al., 2022).

Among the alternative foods, seaweed stands out, used in the diet of broilers (Gatrell et al., 2014; Qadri et al., 2019; Petrolli et al., 2019), laying hens (Carrillo et al., 2012), laying quail and cut quail (Cheong et al., 2016; Abouelezz, 2017). The diversity is related to their chemical composition — determined by geographical and environmental conditions (Ak et al., 2021). Algae of the species sargassum sp are abundantly found on the Brazilian coast, have low concentrations of lipids and high concentrations of proteins, polysaccharides, vitamins, and minerals (Carrillo et al., 2012; Fernandes et al., 2020; Hernández-Cruz et al., 2022), and algae have specific antioxidant properties that can help in the metabolic regulation of animals (Gatrell et al., 2014; Boiago et al., 2019; Hajati et al., 2020).

Algae also have pigmenting properties for the eggs, skin, and muscles of birds, increasing their acceptance by the consumer market (Carrillo et al., 2012), they have a large amount of calcium, therefore, ideal for use in the feed of meat quails, which have a high growth rate and the deficiency in this mineral can cause problems in bone formation, especially tibial dysplasia (Lana et al., 2020), which can affect the growth and performance of birds.

Seaweed species such as Sargassum spp, Gracilaria sp, and Spirulina platensis present a good source of minerals, carbohydrates, and essential amino acids, such as arginine, tryptophan, and phenylalanine, being rich in beta-carotene and vitamins (Abouelezz, 2017; Ekýzoðlu et al., 2020; Hajati et al., 2020; Ismail et al., 2020) and these algae and others of the same genus, when used in bird feeding, promote growth and increase in intestinal flora

Received 10 Oct., 2022
Accepted 12 Dec., 2022
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(Fernandes et al., 2020; Hajati et al., 2020; Jha & Mishra, 2021), with positive results in posture, improving animal performance and feed and water consumption (Carlos et al., 2011).

The objective of the study was to evaluate the productive performance, carcass quality, and intestinal biometry of European quail (Coturnix coturnix Coturnix) consuming diets with the inclusion of seaweed bran (Sargassum sp).

2 Materials and methods

2.1 Experiment location

The present study was carried out at the Laboratory of Rural Constructions and Ambience – LaCRA (7° 13' 51" South, 35° 52' 54" West), at the Federal University of Campina Grande, Paraíba, Brazil, in a masonry shed with three windows. vents that were closed during the night and open during the day under natural conditions, with dimensions of 7.40 x 3.70 x 3.0 meters in length, width, and height, respectively.

2.2 Ethics committee and animals

The procedures performed in this study were approved by the Research Ethics Committee (CEP) of the Federal University of Campina Grande, Paraíba, Brazil, Protocol CEP No. 03/2021.

A total of 240 European quail (Coturnix coturnix Coturnix) chicks, with an initial age of one day and an average weight of 8 ± 0.50 g, acquired from a commercial hatchery, vaccinated, dewormed, and not sexed, were used. The experimental period started in the first until the 42 days of life of the birds.

In the first 14 days of life, the quails were weighed and distributed in four closed protection circles with materials like MDF (medium-density fiberboard), sawdust bedding (shavings), and an average of 5 cm in height and artificially heated, with four 60 W incandescent bulbs. In each circle, 60 quails were housed and provided with feeders and drinkers. At 15 days of age, the birds were housed in galvanized wire cages with dimensions of front 100 x side 50 x height 15 cm, arranged in 5 floors, with each floor divided into three parts, front 33.3 x side 50 x height 15 cm, totaling an area of 0.167 m^2, where 10 quails were housed per cage, the density of 60 birds m^2, where they stayed until the end of the experimental period, at 42 days.

2.3 Feed preparation

Seaweeds of the Sargassum genus, Sargassaceae family, and Sargassum sp species were used to make the seaweed meal, and the collection was carried out by using seaweeds released by the action of sea waves, called "algae aribadas", without harm to the environment and compromise of fauna and flora. The algae were stored in permeable bags with natural ventilation for transport to LACRA, where they were removed and placed in a ventilated environment, and then the cleaning process began.

The cleaning process consisted of the removal of probable epiphytic "contaminants" and fauna associated with the algae, being carried out through three stages washing with fresh running water, draining the sand and salt from the seawater, and thoroughly verifying the presence of pollutants. anthropic substances such as plastics, hair, remains of marine fauna, etc. After the screening and washing process, the raw material was placed in a thin layer on a solvent paper to absorb excess water and dried in the shade for 7 days, then weighed and placed to dry in a forced ventilation oven at 65 °C. °C, remaining at this temperature until reaching constant dry mass.

After removal from the oven, the material was placed to cool naturally and ground in forage until it reached the granulometry of soybean and corn bran. Bran samples were sent for laboratory analysis of micro and macronutrients and material toxicity. The cytotoxicity analysis followed the methodology of Meyer et al. (1982) using the Artemia salina bioassay method.

2.4 Experimental design and experimental procedures

The experiment was arranged in a completely randomized design, with four treatments (four levels of alga inclusion: 0; 2.5; 5, and 7.5%) with 6 replications in each experimental plot.

Feed and water were provided ad libitum. Seaweed meal (Sargassum sp) was included in the diet at increasing levels (0.0; 2.5; 5.0 and 7.5%). During the entire experimental period, the birds were weighed at an interval of seven days, totaling 6 weighings during the experimental period. The lighting program was continuous, with 24 hours of uninterrupted daily light (12 h natural and 12 h artificial) throughout the experimental period. The food (Table 1) was composed according to the composition indicated by the NRC (National Research Council, 2007).

2.5 Performance evaluation and carcass yield

The live weight and weight gain of the birds were evaluated per treatment, obtained weekly in grams by directly weighing the birds using a precision analytical balance (0.1 g resolution). Feed and water consumption were calculated weekly by the ratio of the difference between the amounts offered and the leftovers divided by the number of animals, being rectified according to the mortality of the birds. Feed conversion was calculated as the ratio of feed intake per bird divided by weight gain.

The birds were fasted for 12 hours before slaughter, with only water available at will and, after this period, the slaughter was carried out, stunning and bleeding, plucking in boiling water and removing the feathers, feet, head, and viscera, obtaining the weight of the cleaned and eviscerated carcass. The carcass yield (CY%) was calculated by relating the carcass weight, liver (HL), and gizzard (HG) were weighed using an analytical balance with a precision of ± 0.1. To evaluate intestinal biometry, intestinal length was weighed and measured, the small and large intestines were weighed on a precision scale and the length was determined with the aid of a tape measure.

2.6 Statistical analysis

The data were evaluated employing analysis of variance (ANOVA) and the means compared by the Tukey test at 5% of probability through the GLM procedure (General Linear Model) and the data were submitted to regression by the PROC REG of the SAS® (Statistical Analysis System, 2001).

Table 1. Ingredients and nutritional composition used in the formulation of feed for European quail in two phases.

Ingredients (%)	Sargassum meal inclusion levels (%)			
	0	2.50	5.00	7.50
Phase I (1-21 day)				
Corn	51.82	47.79	43.76	39.72
Soybean meal	42.00	41.97	41.94	41.91
Sargassum Bran	0.00	2.50	5.00	7.50
Dicalcium phosphate	0.14	0.14	0.14	0.14
soy oil	1.04	2.61	4.17	5.73
Core	5.00	5.00	5.00	5.00
Composition calculated				
Met energy Poultry (kcal/kg)	2900	2900	2900	2900
Crude protein (%)	25.00	25.00	25.00	25.00
Total limestone (%)	1.10	1.25	1.41	1.57
Available phosphorus (%)	0.38	0.38	0.38	0.38
Crude fiber (%)	2.96	3.17	3.37	3.56
Sodium (%)	0.22	0.23	0.23	0.24
Arginine (%)	1.52	1.51	1.49	1.47
Threonine (%)	0.80	0.79	0.78	0.77
Isoleucine (%)	0.95	0.93	0.92	0.912
Tryptophan (%)	0.28	0.28	0.27	0.271
Valine (%)	1.02	1.00	0.99	0.973
Leucine (%)	1.85	1.81	1.77	1.726
Lysine (%)	1.33	1.32	1.31	1.303
Methionine (%)	0.38	0.37	0.36	0.355
Methionine + cystine (%)	0.71	0.70	0.68	0.67
Phase II (22-42 day)				
Ingredients (%)	Sargassum meal inclusion levels (%)			
	0	2.50	5.00	7.50
Corn	58.37	54.34	50.31	46.28
Soybean meal	34.30	34.27	34.24	34.21
Sargassum Bran	0.00	2.50	5.00	7.50
Dicalcium phosphate	0.00	0.00	0.00	0.00
soy oil	2.33	3.89	5.45	7.01
Core	5.00	5.00	5.00	5.00
Composition calculated				
Met energy Poultry (kcal/kg)	3050	3050	3050	3050
Crude protein (%)	22.00	22.00	22.00	22.00
Total limestone (%)	1.04	1.19	1.35	1.51
Available phosphorus (%)	0.34	0.34	0.34	0.34
Crude fiber (%)	2.96	3.17	3.37	3.56
Sodium (%)	0.21	0.22	0.23	0.24
Arginine (%)	1.30	1.29	1.27	1.25
Threonine (%)	0.70	0.69	0.68	0.67
Isoleucine (%)	0.81	0.80	0.79	0.78
Tryptophan (%)	0.24	0.24	0.23	0.23
Valine (%)	0.89	0.87	0.86	0.84
Leucine (%)	1.66	1.62	1.58	1.54
Lysine (%)	1.14	1.14	1.13	1.12
Methionine (%)	0.34	0.34	0.33	0.32
Methionine + cystine (%)	0.64	0.63	0.62	0.60

3 Results

Feed consumption showed a significant difference in the first phase ($P = 0.0019$) and the second phase ($P = 0.0051$) with the inclusion of seaweed in the diet, in these phases, the feed consumption showed a quadratic regressive effect and, in the first In this phase, it is observed that with the inclusion of Sargassum, there was a reduction close to 8%, comparing the control group (0%) with the inclusion of 7.5%, in the second phase, this consumption increased with the inclusion of Sargassum, being lower in the control group and similar in the other inclusion levels, and feed consumption in the total period showed no significant difference ($P = 0.4074$) with the inclusion of seaweed in the diet (Table 2).

Water consumption in the first phase was higher with the inclusion of 2.5 and 5.0% of bran, being this consumption in the control group and the inclusion of 7.5% similar; in the second phase, there was a quadratic effect ($P < 0.001$) with the inclusion of Sargassum meal and, in the total period, it was higher at the level of 2.5 and 7.5%, with the control group consuming less water (Table 2).

Weight gain showed a quadratic regressive effect in the first phase with the inclusion of Sargassum, higher in the control group and the lowest at the level of 5 and 7.5%; in the second phase it is variable ($P = 0.0038$) it decreases with the inclusion of 5.0 and 7.5% of bran, getting higher in the control group and with the inclusion of 2.5% of the bran and, in the total period, this gain was similar in the inclusions of 0.0 and 2.5% of the bran and reduced with the inclusion of 5.0 and 7.5% of Sargassum (Table 2). In the second phase and the total phase, the weight gain showed a linear regressive effect with the inclusion of seaweed.

Feed conversion was similar in the first and second phases in birds that consumed 0.0 and 2.5% of bran in the diet, and in the total period, it was lower in birds that received 0.0 and 2.5% of bran. In the first, second, and total phases, there was a linear regressive effect with the inclusion of the Sargassum (Table 2). Comparing the control group (0%) with the level of 2.5%, it is observed that a reduction of 12.91% in feed consumption, an increase of 5.58% in water consumption, and a reduction of 9.09% in weight gain.

In the second phase, feed conversion ($P = 0.0069$) showed a significant difference, where the control group presented a value statistically similar to the levels, and among the inclusion levels, the ones with the highest conversion were 5.0 and 7.5%, while the level of 2.5% presented the lowest value for feed conversion. Feed and water consumption showed a quadratic regressive effect, where the lowest values were in the control group and increased with the inclusion of 2.5%. On the other hand, weight gain and feed conversion showed linear regressive effects.

The slaughter weight was similar in the control group and the birds consumed 2.5 and 5.0% with the inclusion of bran, observing a reduction of 10.59% in the comparison between the control group and the level of 7.5% of Sargassum, and the absolute and relative weight of the carcass, cuts (breast, back, thigh and wing) and organs (heart, liver, gizzard, and intestines) showed no significant difference ($P > 0.05$) and between treatments (Table 3). Even with the greater supply and consumption of fiber with the inclusion of Sargassum bran, up to the level of 7.5% did not influence gizzard weight, as well as the greater amount of salts in the diet, did not affect the weight of the heart and liver (Table 3).

Table 2. Performance of beef quails fed with different levels of inclusion of Sargassum meal in the diet.

Variable	Sargassum meal inclusion levels (%)				SEM	*p-value*	*P-value*	
	0.0	2.5	5.0	7.5			Linear	Quadratic
Phase I: 1 to 21 days of age (g bird^{-1})								
Feed intake	237.5a	209.8b	213.8b	218.6b	11.2	0.001	0.052	0.002[1]
Water intake	712.5c	754.6a	713.4c	749.6b	0.9	< .0001	0.053	0.712
Weight gain	109.9a	99.9b	92.1c	94.6bc	4.4	< .0001	< .000	0.002[2]
Feed conversion	2.1a	2.1a	2.3a	2.3a	0.1	0.061	0.032[3]	0.724
Phase II: 22 to 42 days of age (g bird^{-1})								
Feed intake	481.5b	496.8a	494.0a	496.0a	7.2	0.005	0.012	0.044[4]
Water intake	811.3d	849.7c	867.2b	854.1a	0.8	<.0001	<.0001	<.0001[5]
Weight gain	121.8ab	128.6a	116.3b	116.0b	5.8	0.003	0.027[6]	0.217
Feed conversion	3.9ab	3.8b	4.2a	4.2a	0.2	0.006	0.004[7]	0.572
Final stage 1 to 42 days of age (g bird^{-1})								
Feed intake	719.1a	706.7a	707.8a	714.7a	14.2	0.407	0.652	0.105
Water intake	1523.8c	1604.3a	1580.6b	1603.7a	1.5	<.0001	<.0001	0.001[8]
Weight gain	231.7a	228.6a	208.4b	210.7b	4.4	<.0001	<.0001[9]	0.316
Feed conversion	3.1b	3.0b	3.4a	3.4a	0.1	<.0001	<.0001[10]	0.946

Different letters on the line differ from each other by Tukey's test; SEM = standard error of the mean. [1]$Y = 236.03-11.87x + 0.49x^2$ ($R^2 = 0.92$); [2]$Y = 110.34-5.87x + 0.49x^2$ ($R^2 = 0.73$); [3]$Y = 2.12 + 0.03x$ ($R^2 = 0.65$); [4]$Y = 482.69 + 5.62x-0.53x^2$ ($R^2 = 0.83$); [5]$Y = 810.86 + 21.29x-2.06x^2$ ($R^2 = 0.99$); [6]$Y = 125.17 - 1.19x$ ($R^2 = 0.53$); [7]$Y = 3.88 + 0.05x$ ($R^2 = 0.73$); [8]$Y = 1531.43 + 25.86x-2.30x^2$ ($R^2 = 0.73$); [9]$Y = 232.40 - 3.33x$ ($R^2 = 0.70$); [10]$Y = 3.07 + 0.04x$ ($R^2 = 0.51$).

Table 3. Values of absolute and relative weights of carcass, cuts and edible viscera of European quails at 42 days of age.

Variables	Sargassum meal inclusion levels (%)				SEM	*p-value*	*P-value*	
	0.0	2.5	5.0	7.5			Linear	Quadratic
Absolute weight (g)								
slaughter weight	242.3a	236.6ab	222.1ab	216.6b	13.9	0.014	0.001[1]	0.980
carcass weight	172.1a	173.4a	160.5a	159.4a	12.6	0.137	0.034[2]	0.822
Chest	61.4a	63.5a	59.7a	59.0a	5.4	0.484	0.267	0.513
Back	65.6a	64.9a	60.3a	56.9a	5.7	0.051	0.006[3]	0.544
Thigh	30.6a	31.1a	27.5a	30.3a	2.4	0.072	0.351	0.298
wings	14.4a	13.7a	12.9a	13.1a	1.1	0.121	0.032[4]	0.271
Heart	1.8a	1.8a	1.7a	1.7a	0.1	0.658	0.404	0.581
Liver	4.8a	4.6a	4.4a	4.3a	0.8	0.728	0.242	0.962
Gizzard	4.1a	4.6a	4.2a	4.3a	0.6	0.592	0.847	0.389
Intestine	25.9a	19.9a	22.3a	18.1a	7.0	0.272	0.107	0.763
Relative weight (%)								
Carcass yield	71.1a	73.3a	72.6a	73.6a	3.4	0.594	0.264	0.674
Chest	27.3a	26.8a	26.9a	27.1a	2.6	0.985	0.954	0.713
Back	29.0a	27.4a	27.2a	26.2a	2.6	0.341	0.072	0.772
Thigh	13.6a	13.1a	12.3a	14.0a	1.6	0.358	0.959	0.121
Wings	6.4a	5.8a	5.8a	6.0a	0.5	0.189	0.356	0.051
Heart	0.8a	0.8a	0.8a	0.8a	0.1	0.984	0.915	0.719
Liver	2.1a	1.9a	2.0a	1.9a	0.4	0.911	0.910	0.687
Gizzard	1.8a	1.9a	1.9a	1.9a	0.2	0.790	0.390	0.758
Intestine	11.6a	8.4a	10.0a	8.4a	3.5	0.362	0.216	0.594

Different letters on the line differ from each other by Tukey's test; SEM = standard error of the mean. [1]$Y = 243.18 - 3.66x$ ($R^2 = 0.68$); [2]$Y = 174.07 - 2.04x$ ($R^2 = 0.69$); [3]$Y = 66.56 - 1.23x$ ($R^2 = 0.79$); [4]$Y = 14.29 - 0.19x$ ($R^2 = 0.69$).

The biometric variables showed no statistical difference ($P > 0.05$), where the length of the small intestine showed a quadratic regressive effect with the highest value at the level of 2.5% (Table 4). Quails tend to prolong the small intestine when consuming diets with higher fiber content, improving the absorption of the nutrients offered, but levels of up to 7.5% of Sargassum bran were not enough to change this organ, where digestion and availability occurred. of nutrients for the development of quails.

Table 4. Intestinal biometry of beef quails at 42 days of age, fed on Sargassum meal.

Variables	Sargassum meal inclusion levels (%)				SEM	*p-value*	*P-value*	
	0.0	2.5	5.0	7.5			Linear	Quadratic
Small intestine (cm)	50.9a	53.5a	52.8a	47.1a	6.5	0.362	0.335	0.130
Small intestine (g)	3.7a	4.9a	4.8a	4.2a	0.8	0.088	0.445	0.015[1]
Large intestine (cm)	11.6a	13.0a	11.5a	13.3a	3.0	0.643	0.525	0.842
Large intestine (g)	1.4	1.7a	1.6a	1.6a	0.5	0.802	0.469	0.545
Total length (cm)	62.5a	66.5a	64.3a	60.5a	7.6	0.577	0.547	0.216
Total weight (g)	5.1a	6.6a	6.5a	5.9a	1.2	0.208	0.402	0.054

Different letters on the line differ from each other by Tukey's test; SEM = standard error of the mean; [1]$Y = 3.79 + 0.59x - 0.07x^2$ ($R^2 = 0.66$).

4 Discussion

The lower feed consumption in the birds' initial life stage may be due to the higher percentage of fiber in the diet (Table 1) and the palatability of the feed, which may require time for the quail to adapt and accept the feed and, in the During the entire period, there was the adaptation to the taste, the digestive tract and the microorganisms that digest the fibers (Hajati et al., 2020; Jha & Mishra, 2021) in the birds, with a similar feed intake between treatments.

Feed consumption was higher in phase II, with compensation in this phase, providing similar consumption in the total period. Contrary results were found by Alvarenga et al. (2011) when enriching the feed of broilers with algae extract, not finding a significant difference in feed intake and weight gain.

The reduction in slaughter weight with the inclusion of bran may be related to a higher percentage of fiber in the rations (Table 1) and possible interferences in the absorption of nutrients, since seaweeds in general have properties to reduce poultry fats, which may lead to lower slaughter weight. Similar results were obtained by Ferreira et al. (2019) working with the addition of guava pulp residue as an alternative feed for meat quails. Abouelezz (2017) cites that the inclusion of Spirulina powder (1% in the feed) increased weight and body weight gain and caused better feed conversion rates in Japanese quails during the birds' growth period. The presence of fiber induces the greater activity of this organ, aiming to improve digestion and absorption of the diet with high viscosity and consequent development of organs and birds.

Seaweeds of the genus Schizotrichium can be added to broiler rations (2%), without compromising performance, carcass, and organ yield, improving the fatty acid profile of the meat (Petrolli et al., 2019). Boiago et al. (2019) cite that the use of the microalgae Spirulina platensis in the diet of quails improved egg quality, reducing the levels of undesirable saturated fatty acids and increasing the levels of monounsaturated fatty acids, which are beneficial to the health of consumers.

Carrillo et al. (2012) mention that concentrations of 4, 6, and 8% of the alga Sargassum spp. in chicken diets significantly reduced cholesterol levels in eggs, without affecting their physical quality and favorably increases yolk color, possibly attributed to the presence of lutein, zeaxanthin, fucoxanthin, and carotenoids present in brown algae. Improved effects on feed conversion were observed by Carlos et al. (2011), in broilers supplemented with Lithothamnium calcareum, which showed greater weight gain and better breast yield, due to improved feed conversion. Hajati & Zaghari (2019) cite that the use of 5 g of Spirulina platensis per kilogram in the diet increased body weight gain and efficiency in the production of European quails from 1 to 35 days of age.

The inclusion of sargassum meal up to the level of 7.5% did not affect the yields in commercial cuts and carcass. Alfaia et al. (2021) cite that the use of 10% in the basal diet with Chlorella Vulgaris algae did not affect the performance of broilers, but increased tenderness, and yellowness (b*) and total carotenoids in breast and thigh meats of birds. Cheong et al. (2016) cite that diets with up to 4% Spirulina improved the performance, carcass composition, color, and sheer force of the meat of growing Japanese quail.

Even quails increasing water consumption and consuming greater amounts of fiber with the addition of Sargassum bran, up to the level of 7.5% inclusion was not enough to change the length and weight of the large intestine, where absorption occurs. of water and greater bacterial digestion of fibers, and this effect may be associated with an improvement in the capacity of the gastrointestinal tract, especially the relative weight of the small intestine (Hajati et al., 2020).

Fernandes et al. (2020) cite that laying hens fed diets supplemented with Dunaliella salina marine microalgae, the length of the villi and the villus: crypt ratio of the duodenum and ileum segments and the metabolism of carotenoids in the liver increased as an effect of dietary microalgae supplementation. It stimulates the formation of the microbiome to degrade fibers and increase its fermentability, increasing the size of the large intestine, modulating the microbiota, benefiting the large intestine, and improving immune functions (Jha & Mishra, 2021). Hajati et al. (2020) cite that quails supplemented with Spirulina platensis (0.5%), kept under heat stress (34 ± 1 oC for 8 h), had a higher population of Lactobacilli bacteria in the ileum and a reduction in the population of Escherichia coli.

Similar results for this research were found by Sugiharto et al. (2018) using the macroalgae Spirulina Parantis (SP) at levels 0.2 and 0.3 g/ reported no significant difference in carcass yield and prime cuts compared to the control group. However, Cheong et al. (2015) found an increase in relative breast weight with the inclusion of up to 5 g/kg. The difference between the results may be due to the different levels of inclusion and different macroalgae species used in the assays. These results suggest the consolidation of the use of Sargassum sp in the feeding of meat quails since it did not compromise the carcass and prime cuts in relation to the control group.

5 Conclusion

The inclusion of macroalgae resulted in a reduction in feed consumption in the first phase and an increase in the second phase, without compromising the development of the birds. The algae sargassum sp has potential as an additive in the diets of beef quails and can be included in up to 7.5% without prejudice to the performance of the birds, carcass yield, and organ biometry.

References

Abouelezz, F. M. K. (2017). Evaluation of *Spirulina algae* (*Spirulina platensis*) as a feed supplement for Japanese quail: nutritional effects on growth performance, egg production, egg quality, blood metabolites, sperm-egg penetration, and fertilization. *Egyptian Poultry Science*, 37(3), 707-719. http://dx.doi.org/10.21608/epsj.2017.5390.

Ak, İ., Çankiriligil, E. C., Türker, G., & Sever, O. (2021). Assessment of light intensity and salinity regimes on the element levels of brown macroalgae, Treptacantha barbata: application of response surface methodology (RSM). *Food Science and Technology*, 41(4), 944-952. http://dx.doi.org/10.1590/fst.25220.

Alfaia, C. M., Pestana, J. M., Rodrigues, M., Coelho, D., Aires, M. J., Ribeiro, D. M., Major, V. T., Martins, C. F., Santos, H., Lopes, P. A., Lemos, J. P. C., Fontes, C. M. G. A., Lordelo, M. M., & Prates, J. A. M. (2021). Influence of dietary Chlorella Vulgaris and carbohydrate-active enzymes on growth performance, meat quality and lipid composition of broiler chickens. *Poultry Science*, 100(2), 926-937. http://dx.doi.org/10.1016/j.psj.2020.11.034. PMid:33518146.

Alvarenga, R. R., Rodrigues, P. B., Cantarelli, V. S., Zangeronimo, M. G., Silva, J. W. Jr., Silva, L. R., Santos, L. M., & Pereira, L. J. (2011). Energy values and chemical composition of spirulina (*Spirulina platensis*) evaluated with broilers. *Revista Brasileira de Zootecnia*, 40(5), 992-996. http://dx.doi.org/10.1590/S1516-35982011000500008.

Arif, M., Rehman, A. U., Naseer, K., Abdel-Hafez, S. H., Alminderej, F. M., El-Saadony, M. T., El-Hack, M. E. A., Taha, A. E., Elnesr, S. S., Salem, H. M., & Alagawany, M. (2022). Effect of Aloe vera and clove powder supplementation on growth performance, carcass and blood chemistry of Japanese quails. *Poultry Science*, 101(4), 101702. http://dx.doi.org/10.1016/j.psj.2022.101702. PMid:35172233.

Boiago, M. M., Dilkin, J. D., Kolm, M. A., Barreta, M., Souza, C. F., Baldissera, M. D., Santos, I. D., Wagner, R., Tavernari, F. C., Silva, M. L. B., Zampar, A., Stivanin, T. E., & Silva, A. S. (2019). Spirulina platensis in Japanese quail feeding alters fatty acid profiles and improves egg quality: benefits to consumers. *Journal of Food Biochemistry*, 43(7), e12860. http://dx.doi.org/10.1111/jfbc.12860. PMid:31353724.

Brunelli, P. F., Romania, H. F., Cultri, G. R. S., Santos, H. V., Dias, L. T. S., & Silva, J. D. T. (2018). Bem-estar e qualidade de ovos de codornas alimentadas com extratos de camomila e passiflora. *Boletim de Indústria Animal*, 75, 1-11. http://dx.doi.org/10.17523/bia.2018.v75.e1432.

Carlos, A. C., Sakomura, N. K., Pinheiro, S. R. F., Toledano, F. M. M., Giacometti, R., & Silva, J. W. D. Jr. (2011). Uso da alga *Lithothamnium calcareum* como fonte alternativa de cálcio nas rações de frangos de corte. *Revista Ciência e Agrotecnologia*, 35(4), 833-839. http://dx.doi.org/10.1590/S1413-70542011000400025.

Carrillo, S., Bahena, A., Casas, M., & Carranco, M. E. (2012). El alga Sargassum spp. como alternativa para reducir el contenido de colesterol en el huevo. *Revista Cubana de Ciencia Avícola*, 46, 181-186.

Cheong, D. S. W., Kasim, A., Sazili, A. Q., Hishamuddin, O. M. A. R., & Teoh, J. Y. (2015). Effect of supplementing spirulina on live performance, carcass composition and meat quality of Japanese quail. *Walailak Journal of Science and Technology*, 13, 77-84.

Cheong, D. W. W., Kasim, A., Sazili, A. Q., Omar, H., & Teoh, J. Y. (2016). Effect of supplementing Spirulina on live performance, carcass composition and meat quality of Japanese quail. *Walailak Journal of Science and Technology*, 13, 77-84.

Ekýzoðlu, H., Ülger, Ý., Kalýber, M., & Ayaþan, T. (2020). Effects of Spirulina (Algae) supplementation to Japanese quail (Coturnix coturnix Japonica) diets on growth performance and carcass traits. *The Indian Journal of Animal Sciences*, 90(6), 923-927. http://dx.doi.org/10.56093/ijans.v90i6.105006.

Fernandes, R. T. V., Gonçalves, A. A., & Arruda, A. M. V. (2020). Production, egg quality, and intestinal morphometry of laying hens fed marine microalga. *Revista Brasileira de Zootecnia*, 49, e20200011. http://dx.doi.org/10.37496/rbz4920200011.

Ferreira, T. S., Lana, S. R. V., Lana, G. R. Q., Madalena, J. A., Silva, L. C. L., & Torres, E. C. (2019). Resíduo de acerola em dietas para codornas. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 71(1), 259-266. http://dx.doi.org/10.1590/1678-4162-9965.

Gatrell, S., Lum, K., Kim, J., & Lei, X. G. (2014). Nonruminant nutrition symposium: potential of defatted microalgae from the biofuel industry as an ingredient to replace corn and soybean meal in swine and poultry diets. *Journal of Animal Science*, 92(4), 1306-1314. http://dx.doi.org/10.2527/jas.2013-7250. PMid:24496842.

Hafez, H. M., & Attia, Y. A. (2020). Challenges to the poultry industry: current perspectives and strategic future after the COVID-19 outbreak. *Frontiers in Veterinary Science*, 7, 516. http://dx.doi.org/10.3389/fvets.2020.00516. PMid:33005639.

Hafsa, S. H. A., & Hassan, A. A. (2022). The effect of sargassum siliquastrum supplementation on growth performance, cecal fermentation, intestine histomorphology, and immune response of japanese quails. *Animals*, 12(4), 432. http://dx.doi.org/10.3390/ani12040432. PMid:35203140.

Hafsa, S. H. A., Zeweil, H. S., Zahran, S. M., Ahmed, M. H., Dosoky, W., & Rwif, N. A. (2019). Effect of dietary supplementation with green and brown seaweeds on laying performance, egg quality, blood lipid profile and antioxidant capacity in Japanese quail. *Egyptian Poultry Science*, 39(1), 41-59. http://dx.doi.org/10.21608/epsj.2019.28828.

Hajati, H. M., & Zaghari, M. (2019). Effects of Spirulina platensis on growth performance, carcass characteristics, egg traits and immunity response of Japanese quails. *Iranian Journal of Applied Animal Science*, 9, 347-357.

Hajati, H., Zaghari, M., & Oliveira, H. C. (2020). *Arthrospira* (*Spirulina*) *Platensis* can be considered as a probiotic alternative to reduce heat stress in laying Japanese quails. *Brazilian Journal of Poultry Science*, 22(1), eRBCA-2018-0977. http://dx.doi.org/10.1590/1806-9061-2018-0977.

Hernández-Cruz, K., Jiménez-Martínez, C., Perucini-Avendaño, M., Cid, L. E. M., Perea-Flores, M. J., Gutiérrez-López, G. F., & Dávila-Ortiz, G. (2022). Chemical and microstructural characterization of three seaweeds species from two locations of Veracruz, Mexico. *Food Science and Technology*, 42, e41421. http://dx.doi.org/10.1590/fst.41421.

Ismail, G. A., Gheda, S. F., Abo-Shady, A. M., & Abdel-Karim, O. H. (2020). *In vitro* potential activity of some seaweeds as antioxidants and inhibitors of diabetic enzymes. *Food Science and Technology*, 40(3), 681-691. http://dx.doi.org/10.1590/fst.15619.

Jha, R., & Mishra, P. (2021). Dietary fiber in poultry nutrition and their effects on nutrient utilization, performance, gut health, and on the environment: a review. *Journal of Animal Science and*

Biotechnology, 12(1), 51. http://dx.doi.org/10.1186/s40104-021-00576-0. PMid:33866972.

Lana, V. R. S., Lana, G. R. Q., Barros, R. F. Jr., Silva, M. P. L., Santos, D. S., & Leão, A. P. A. (2020). Utilização de conchas de sururu como fonte alternativa de cálcio para codornas japonesas. *Revista Ciência Agrícola*, 18(1), 21-27. http://dx.doi.org/10.28998/rca.v18i1.8222.

Meyer, B. N., Ferrigni, N. R., Putnam, J. E., Jacobsen, L. B., Nichols, D. E., & McLaughlin, J. L. (1982). Brine shrimp: a convenient general bioassay for active plant constituents. *Planta Medica*, 45(5), 31-34. http://dx.doi.org/10.1055/s-2007-971236. PMid:17396775.

National Research Council – NRC. (2007). *Nutrition requirement of poultry* (9th ed.). Washington, DC: National Academy of Science Press.

Nnadi, G. L., Simeon-Ahaotu, V. C., Ríos-Escalante, P. D., & Ahaotu, E. O. (2022). Replacement level of rubber seed cake for soybean meal on the growth of Japanese quail. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, 82, e243242. http://dx.doi.org/10.1590/1519-6984.243242.

Petrolli, T. G. I., Petrolli, O. J. I. I., Pereira, A. S. C., Zotti, C. A. I., Romani, J. I. V., Villani, R. I. V., Leite, F. I. V., & Zanandréa, F. M. (2019). Effects of the dietary supplementation with a microalga extract on broiler performance and fatty-acid meat profile. *Brazilian Journal of Poultry Science*, 21(3), eRBCA-2018-0958. http://dx.doi.org/10.1590/1806-9061-2018-0958.

Qadri, S. S. N., Biswas, A., Mandal, A. B., Kumawat, M., Saxena, R., & Nasir, A. M. (2019). Production performance, immune response and carcass traits of broiler chickens fed diet incorporated with Kappaphycus alvarezii. *Journal of Applied Phycology*, 31(1), 753-760. http://dx.doi.org/10.1007/s10811-018-1498-y.

Statistical Analysis System – SAS. (2001). *Statistical Analysis System user's guide. Version 9.1*. Cary: Statistical Analysis System Institute.

Sugiharto, S., Yudiarti, T., Isroli, I., & Widiastuti, E. (2018). Effect of feeding duration of Spirulina platensis on growth performance, haematological parameters, intestinal microbial population and carcass traits of broiler chicks. *South African Journal of Animal Science*, 48(1), 98-107. http://dx.doi.org/10.4314/sajas.v48i1.12.

Xavier, H. P. F., Leandro, N. S. M., Conceição, E. C., Mascarenhas, A. G., Arnhold, E., Mello, H. H. C., Borges, K. M., Oliveira, M. D., & Pereira, L. S. (2020). Utilização de extrato de goiaba como aditivo antioxidante na ração de codornas (Coturnix japonica). *Revista Brasileira de Saúde e Produção Animal*, 21, 1-10.