



Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/13562

DOI URL: <http://dx.doi.org/10.21474/IJAR01/13562>



RESEARCH ARTICLE

FEEDING FREQUENCY AND DENSITY OF MICROALGAE PASTE (*CHLORELLA VULGARIS*) IN THE DIET OF DEKALB UNDER BATTERY CAGE SYSTEM

Hannah F. Gan¹ and Ken N. Falculan²

1. Agriculturist 1, Livestock Program, Department of Agriculture, Regional Field Office 4-MIMAROPA Odiongan, Romblon, Philippines.
2. Faculty, College of Agriculture, Romblon State University, Odiongan, Romblon, Philippines.

Manuscript Info

Manuscript History

Received: 19 August 2021

Final Accepted: 22 September 2021

Published: October 2021

Key words:-

Chlorella Vulgaris, Density, Egg Quality, Frequency, Laying Performance, Microalgae Paste

Abstract

Poultry products are the major source of animal protein for most people throughout the world and egg production is the major index of performance of commercial layer business and the avenue in the potential increase of income from the enterprise which focuses on egg yield, weight of eggs, and increasing their quality production to enhance economic performance. Microalgae is certainly an interesting solution, it aims to increase its value as an animal feed additive in new commercial applications. The experimental research was used in this study to evaluate the laying performance and egg quality of DeKalb under two feeding regimen such as feeding density and frequency of microalgae paste *Chlorella vulgaris* under battery type cage system. The experiment was conducted in a completely randomized design with a period of 30 days with 81 Dekalb of the same age. The experimental diet used were commercial feeds, microalgae paste and feeding frequencies of 4 times, 3 times and 2 times. Egg characteristics such as; total number of eggs, egg weight (g), egg length (mm), egg width (mm) and shape index (%) were computed based on the data from feeding frequency and density. The costs of feeds and price of grown Dekalb and some material used were used in the computation of return on investment. Based on the result, the effect on the external quality of eggs fed under different feeding densities and frequencies on egg production, egg width, egg weight, egg length and shape index resulted to not significant the null hypothesis was accepted. The internal quality, the effect of different feeding densities on albumen height, albumen weight and yolk width also statistically not significant. Supplementation of microalgae *Chlorella vulgaris* on hen diet can be included as a dietary supplement for laying hens up to 80% of the diet to produce quality eggs.

Copy Right, IJAR, 2021., All rights reserved.

Introduction:-

Poultry farming involved raising chickens in the backyard for daily egg production and family consumption. Despite significant technological advancement in the egg industry, a number of production and marketing problems were encountered. Increased egg production, improved feed efficiency and adaptation of egg quality to consumer

Corresponding Author:- Hannah F Gan

Address:- Agriculturist 1, Livestock Program, Department of Agriculture, Regional Field Office 4-MIMAROPA Odiongan, Romblon, Philippines.

preferences have contributed significantly to the success of the poultry industry. Poultry farming today is a huge business that is split into several operations including hatcheries, pullet farms for meat production, or farms for egg production. The industry has always been inclined to use the cheapest ingredients to maximize profit. As such ingredients do not always support optimum productivity, they are included in small amounts or efforts are made to improve their nutritive value. The use of alternative feed ingredients in poultry diets can be an interesting choice from an economically standpoint. Poultry products are the major source of animal protein for most people throughout the world and egg production is the major index of performance of commercial layer business because it accounts for about 90% of the income from the enterprise⁷. The economic success of a laying flocks depends on the number of quality eggs produced. In poultry farms, breeders used to focus on increasing egg yield, weight of eggs, and increasing their quality production to enhance economic performance and market portion¹².

The poultry industry relies on a few major ingredients for feed formulation. Microalgae is certainly an interesting solution, it aims to increase its value as an animal feed additive in new commercial applications⁸. Several feeding experiments have shown that microalgae from different species can be successfully included into poultry diets and can have a beneficial effect on the health, performance, and quality of poultry meat and eggs. Nutritional value should be explored as replacement for major cereal grains in animal diets to help sustain growth in animal production. The high-level nutrient content of microalgae has been proven to be effective live feeds used not only in aquaculture but also used to provide a safe source of nutrients for poultry and livestock. Comprehensive nutritional studies have shown that microalgae can be successfully used as feed ingredients in poultry nutrition. They can have a positive effect on performance indicators and immune function, and have a beneficial effect on the quality of meat and eggs. They can be effectively used as a source of carotenoids for pigmentation of egg yolks⁶. Some species of seaweed and microalgae are known to contain protein levels similar to those of traditional protein sources, such as meat, egg, soybean, and milk².

In the Philippines egg production has a promising potential. Egg quality is one of the most important issues in the poultry industry, influencing the economic profitability of egg production and hatchability. Egg quality comprises a number of aspects related to the shell, albumen and yolk and may be divided into external and internal qualities¹¹. Proper attention to production, distribution and point-of-sale stages is essential to maintain egg quality. Therefore, information on egg quality characteristics and production performance of the layer under different feeding frequency will be useful for local poultry raisers and to both large scale and smallholder farmers to have a better quality and improve egg production. Maintaining the quality of fresh eggs from producer to consumer is one of the main problems faced by those who sell eggs. Thus, the study was designed to determine the efficacy of micro algae paste on the laying performance and egg quality of DeKalb.

Methodology:-

The experimental research was used in this study to evaluate the laying performance and egg quality of DeKalb under two feeding regimen such as feeding density of microalgae paste (*Chlorella vulgaris*) and feeding frequency under battery type cage system. The Completely Randomized Design (CRD) was used to identify the effect of different treatments namely factor A: different feeding densities of 110g commercial feeds, 90g commercial feeds + 20g microalgae paste and 70g commercial feeds + 40 microalgae paste and factor B: different feeding frequencies of 4 times, 3 times and 2 times.

Population of the Study

The population of the study was composed of eighty-one (81) DeKalb randomly assigned to three dietary treatments. Each treatment was replicated 3 times, each replication comprises with 3 layers to evaluate the laying capacity and egg quality of DeKalb chickens fed with different levels of microalgae paste *Chlorella vulgaris* in different feeding frequencies under cage system.

Materials:-

The materials and instruments used in the study were the following: 81 DeKalb of the same age; Microalgae paste (*Chlorella vulgaris*); Vision feeds-laying mash; petri dish; record book; ballpen; waterers- made of bamboo slats; feeders made of G.I plain sheet size 4'' wide and 8 ft. long; tying wire; 81 cages made of bamboo measuring 1 sq.ft./bird; nails size 2 and size 4; amazon screen size 1; 5w bulbs; coconut palm fronds, plywood size ¼ ; wood size 1 x 2; Orocan; rivet; Vulcaseal and Rattan. The instruments used were Laptop-brand Asus, Model: X441S; Digital weighing scale-brand OHAUS, Model: PA-84; Oppo -Camera - Model: A37; and digital caliper.

Procedure

The procedures in the conduct of the experimental study are the following; construction of the experimental cage, purchase of experimental hens, feeds, supplies and materials needed, management of experimental hens like cleaning, feeding management, water management, data collection, weighing and statistical data analysis.

Construction of the Experimental Poultry Housing

The poultry house constructed with locally made materials, subdivided the cages in equal size measuring 1 sq. ft./bird. The height of floor from the ground was 80 cm with a total length of 732 cm. A similar design of materials used bamboo slats for the walling and coconut shingles as roofing. Cages were thoroughly prepared and cleaned upon the arrival of the layer chickens.

Experimental Layer Chickens

The experimental DeKalb white layer chickens were purchased from a reputable local poultry raiser. The experimental material was randomly selected.

Preparation of Microalgae Paste

Microalgae paste *Chlorella vulgaris* was obtained at the University of the Philippines Visayas (UPV) from the Institute of Aquaculture- College of Fisheries and Ocean Sciences/Museum of Natural Sciences University of the Philippines Visayas, Mia-gao, Iloilo. Microalgae paste products were refrigerated under cold condition to ensure their nutritional quality.

Feeding and Waste Management

Ultra-MV vitamins with anti-stress were administered it is an oral multivitamin supplement added to water for the layers to recover from the stress of transport. Prior to the experimental period, the DeKalb layers were allowed a 1-month adaptation before the start of data collection. All groups were fed with the control diet: feeding frequency of 2 times a day (4:00 in the morning and 1:00 in the afternoon), 3 times a day (4:00 in the morning, 10:00 am and 1:00 pm) and 4 times a day (4:00 am, 10:00 am, 1:00 pm and in 4 pm). They were fed with standard feeding density for laying hens with 110 grams per day. Layers were given clean water throughout the whole day and waterers were washed and cleaned daily in the morning. A lighting schedule of 4pm-8pm in the evening and 4am-9am in the morning was applied during the laying period. Poultry house was cleaned daily to ensure the cleanliness of the study area. Application of rice hull once a week was done to control the odor coming from the wastes of the experimental layers. Strict sanitary measures were followed during the experimental period as a preventive measure to protect the birds from any harmful microorganisms. Uniformity in the management practices was maintained throughout the laying period.

Data Gathering Procedure

The data gathered were the number of eggs laid, egg weight, egg width, egg length, shape index, albumen height, albumen weight and yolk width under different feeding densities and feeding frequencies. All data were recorded throughout the experimental period.

Measurement of External Characteristics

The individual egg was collected and weighed on a digital balance to the nearest of 0.01 g accuracy. The egg length and width of egg were measured (mm) with the use of digital caliper and Shape Index (SI) was calculated as to the ratio of width to length times 100 using the following equation: Shape Index = [egg width / egg length] × 100 (Altuntas and Sekeroglu, 2008). It was calculated using the following formula:

$$SI = \frac{W}{L} \times 100 \text{ Where: } W = \text{Width of eggs} \\ L = \text{Length of eggs}$$

Measurement of Internal Characteristics

The internal components were obtained by carefully making an opening around the sharp end of the egg, large enough to allow passage of both the albumen and the yolk through it without mixing their contents together. The yolk is then carefully separated from the albumen with the use of spoon and placed in a petri dish for weighing. Simultaneously, the associated albumen is placed on another petri dish and weighed. Both petri dish used in weighing the egg contents had initially being weighed and the difference in the weights of the petri dish after and before the egg component is taken as the weight of the egg components. The albumen height, and yolk width were measured in (mm) with the help of digital caliper and albumen weight was measured in grams (g) using a digital

balance to the nearest of 0.01 g accuracy. After each weighing, the Petri dishes were washed in clean water and wiped dry before the next weighing.

Data Processing and Statistical Procedure

Statistical Analysis of Data on the total number of eggs, egg weight, egg width, egg length, shape index, albumen height, albumen weight, and yolk width were processed and analyzed using analysis of variance.

Result and Discussion:-

Number of laid eggs

Result showed table 1 that there were no significant differences on the laying performance of DeKalb after feeding with different levels of microalgae paste with the combination of commercial feeds at 30 days of laying period. In addition, the number of eggs was not significantly affected by the different feeding frequencies. Likewise, the results showed that there was no interaction effect between different feeding frequencies fed with different feeding densities of microalgae paste. The economic increase for poultry production is measured according to the total number of produced eggs.

Table 1:- Number of eggs as affected by different feeding density and different feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	26	22	24	24 ^a
T ₂ 90g commercial feeds +20g microalgae paste	22	23	25	23 ^a
T ₃ 70g commercial feeds +40g microalgae paste	24	21	24	23 ^a
Mean	24 ^a	22 ^a	24 ^a	

Figure 1:- The number of eggs laid.



Egg Weight

Results showtable 2 revealed that there were significant differences among the egg weights fed with different densities of microalgae paste *Chlorella vulgaris* with the combination of commercial ration. Likewise, the egg weight of DeKalb fed in different feeding frequencies were not significantly affected. Different feeding densities and frequencies of microalgae paste has no interaction effect on the egg quality of Dekalb. The egg weight was influenced by hen's breed, genetic factors, age of laying hen, season, climatic conditions, nutrition, and individuality of laying hens³.

Table 2:- Egg weight (grams) as affected by different feeding density and different feeding frequency of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	59.68	57.66	60.14	59.16 ^{ab}
T ₂ 90g commercial feeds +20g microalgae paste	62.23	61.05	57.69	60.32 ^a
T ₃ 70g commercial feeds +40g microalgae paste	57.08	55.44	59.69	57.40 ^b
I. MEAN	II. 59.66 ^A	III. 58.05 ^A	IV. 59.18 ^A	V.

Figure 2:- Weighing of egg sample.**Egg Width**

Shown in table 3 that there were significant differences on the egg width of DeKalb as influenced by different feeding densities of microalgae paste *Chlorella vulgaris*. However, the egg width of the DeKalb white was not significantly affected by different feeding frequency. T₂ has a width of 43.45^{mm} compared to T₃ with 42.19^{mm}, but not significantly different to T₂ of 43.45^{mm}. T₂ and T₃ has comparable egg widths. However, feeding frequencies, feeding frequency of 4 and 3 times had the same egg width 42.74^{mm}, but not significantly different to 2 times with 42.66^{mm}. On the other hand, different feeding frequencies had no significant effect on the egg width.

Table 3:- Egg width (mm) as affected by different feeding densities and different feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	42.68	42.28	42.53	42.50 ^{ab}
T ₂ 90g commercial feeds +20g microalgae paste	43.65	44.20	42.49	43.45 ^a
T ₃ 70g commercial feeds +40g microalgae paste	41.87	41.74	42.97	42.19 ^b
Mean	42.74 ^a	42.74 ^a	42.66 ^a	

Figure 3:- width of sample egg.**Egg Length**

Table 4 showed that there were no significant differences on the egg quality of DeKalbin terms of egg length in different feeding frequency and density of microalgae paste combined with commercial feeds. Likewise, the results showed that there was no interaction effect between different feeding frequencies and different feeding densities of microalgae paste *Chlorella vulgaris*. Highest mean egg length was recorded in T₂ has 57.50^{mm}, while the least egg length was recorded in T₃ 56.48^{mm}. Likewise, feeding frequencies of 2 times has the greater mean egg length of 57.17^{mm} and 3 times having the least with 56.56^{mm}. The results indicated that the length of eggs was not significantly affected by the microalgae paste with the combination of commercial feeds with different feeding frequencies. Egg length varies with genotype and is also affected by non-genetic factors⁵.

Table 4:- Egg length (mm) as affected by different feeding densities and different feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	

T ₁ 110g commercial feeds	56.78	56.18	57.22	56.72 ^a
T ₂ 90g commercial feeds +20g microalgae paste	58.42	57.55	56.52	57.50 ^a
T ₃ 70g commercial feeds +40g microalgae paste	55.69	55.95	57.79	56.48 ^a
Mean	56.96 ^a	56.56 ^a	57.17 ^a	

Figure 4:- length of sample egg.

Shape Index

Table 5 showed that there were no significant differences in the shape index of DeKalb after feeding microalgae paste with different feeding densities and feeding frequencies and the combination of commercial feeds. There was no interaction effect between different feeding density and feeding frequencies of microalgae paste with the combination of commercial feeds. Shape index in T₂ had a highest mean (75.57%) compared to T₃ (74.71%), but not significantly different to T₁ (74.93%). T₁ and T₃ had comparable but statistically not significant in shape index. On the other hand, shape index of DeKalb in the feeding frequency of 3 times has the highest percentage (75.55%) followed by 4 times (75.035) and 2 times (74.63%) respectively.

Table 5:- Shape index of eggs (%) as affected by different feeding densities and different feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	75.19	75.26	74.35	74.93 ^a
T ₂ 90g commercial feeds +20g microalgae paste	74.73	76.79	75.19	75.57 ^a
T ₃ 70g commercial feeds +40g microalgae paste	75.18	74.60	74.36	74.71 ^a
Mean	75.03 ^a	75.55 ^a	74.63 ^a	

Albumen Height

Table 6 showed that there were no significant differences on the egg quality of DeKalb in terms of albumen height after feeding in different densities and feeding frequencies of microalgae paste. Likewise, the results showed that there was no interaction effect between different feeding frequencies and feeding densities of microalgae paste. Egg albumen height in T₂ had a higher mean (7.05^{mm}) compared to T₃ (6.73^{mm}), but not significantly different to T₁ (6.94^{mm}). T₁ and T₃ had comparable and not significantly different albumen heights, mean on feeding frequencies of 4 times and 2 times showed comparable results with a total mean of (6.93^{mm}) and the lowest is 3 times with (6.87^{mm}). This indicates that the albumen height of DeKalb was not significantly affected by the microalgae paste with the combination of commercial feeds with different feeding frequencies. Albumen is a major determinant of internal egg quality. Higher values for albumen height are attributable to the freshness of eggs and proper age of hens. The higher albumen height observed in the eggs of the hen in this study indicates the superiority of the quality of the eggs. Albumen height (6.87-7.05^{mm}) observed in the study is within the range value for superior quality. Maybe because layers were not exposed to ammonia⁹.

Table 6:- Albumen height (mm) as affected by different feeding densities and feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency	
-----------------------------	-------------------	--

	4 times	3 times	2 times	Mean
T ₁ 110g commercial feeds	6.90	6.91	6.99	6.94 ^a
T ₂ 90g commercial feeds +20g microalgae paste	7.14	7.13	6.89	7.05 ^a
T ₃ 70g commercial feeds +40g microalgae paste	6.73	6.55	6.90	6.73 ^a
Mean	6.93 ^a	6.87 ^a	6.93 ^a	

Albumen Weight

Table 7 showed that there were significant differences among the albumen weights of DeKalb after feeding different densities of microalgae paste *Chlorella vulgaris* with the combination of commercial ration. Likewise, the egg quality of DeKalb layers was not significantly affected by the different feeding frequencies. There were no interaction effects between densities of microalgae paste and feeding frequencies. T₂ had a higher albumen weight (32.70g), compared to T₃ (31.11g), but not significantly different to T₁ (32.12g). T₁ and T₃ had comparable and not significantly different albumen weights. Egg size increased with age of the hen with a proportionately larger increase in yolk weight than albumen weight as protein was transferred through the yolk membrane from the albumen. Egg size in this study ranged from medium to large. The albumen is the major contributor to egg size and suggested that selection for increased egg size should increase the relative amount of albumen¹⁰.

Table 7:- Albumen weight (grams) as affected by different feeding densities and feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	32.67	31.38	32.32	32.12 ^{ab}
T ₂ 90g commercial feeds +20g microalgae paste	34.15	32.79	31.17	32.70 ^a
T ₃ 70g commercial feeds +40g microalgae paste	31.22	30.15	31.96	31.11 ^b
Mean	32.68 ^a	31.44 ^a	31.81 ^a	

Yolk Width

Table 8 showed that there were no significant differences among the yolk width of DeKalb at 30 days of feeding with different densities of microalgae paste with the combination of commercial feeds. Likewise, different feeding frequencies had no significant effect on the yolk width of DeKalb after feeding of different densities of microalgae paste with the combination of commercial feeds. There was no interaction effect between different feeding densities of microalgae paste with the combination of commercial feeds and different feeding frequencies. The highest yolk width was obtained in T₃ (42.83^{mm}), followed by T₂ (42.59^{mm}), and T₁ (42.52^{mm}) having the lowest yolk width. Likewise, yolk width of DeKalb white fed with feeding frequency of 3 times has the highest average mean of (42.72^{mm}), followed by 4 times with (42.66^{mm}) and 2 times got the lowest yolk width with (42.55^{mm}).

Table 8:- Yolk width of eggs (mm) as affected by different feeding densities and feeding frequencies of microalgae paste *Chlorella vulgaris* at 30 days of laying period.

Density of Microalgae Paste	Feeding Frequency			Mean
	4 times	3 times	2 times	
T ₁ 110g commercial feeds	42.30	42.57	42.69	42.52 ^a
T ₂ 90g commercial feeds +20g microalgae paste	42.77	42.68	42.31	42.59 ^a
T ₃ 70g commercial feeds +40g microalgae paste	42.92	42.92	42.65	42.83 ^a
Mean	42.66 ^a	42.72 ^a	42.55 ^a	

Figure 8:- yolk width sample.

Financial Aspects

Based on the results of the study, T2 representing a feeding density of 90g commercial feeds with 20g microalgae paste exhibited a better performance compared to the other treatments. Evidence for the performance has been demonstrated wherein the highest egg production recorded in T1 with 110g commercial feeds, while egg weight, egg width, egg length, shape index, albumen height and albumen weight were recorded highest in T2, and yolk width in T3. Although T2 showed a positive effect in egg quality and is promising for its potential use as feeding ration, the return of investment showed that a local farmer cannot afford the expenses/price of microalgae paste as fed ration for layers. If a farmer was offered a choice between using the commercial layer feeds and the microalgae paste, they will mostly prefer to use the low cost/cheap feeding but shows remarkable results. Furthermore, based on the study's financial aspects, the gross income is Php28,340.00 with the total expenses of Php59,250.00 which results to the ROI of 52%. With this, the farmers need to be careful with the nutrition of the chickens as higher egg weight demands a better nutrition, which if not provided can seriously impair their productivity and also the hatchability of the eggs⁴. In addition, the poultry raisers too, need to be made aware of clean egg production and storage so as to ensure a better market acceptability and price of the eggs¹.

Conclusions:-

The effect of different feeding densities on egg production (external), egg width, egg weight, egg length and shape index were not significant; therefore, the null hypothesis was accepted. Likewise, the effect of different feeding frequencies on egg production, egg width, egg weight, egg length and shape index were not significant; therefore, the null hypothesis was accepted.

The effect of different feeding density(internal) on albumen height, albumen weight and yolk width were not significant; therefore, the null hypothesis was accepted. Likewise, the effect of different feeding frequencies on albumen height, albumen weight and yolk width were not significant; therefore, the null hypothesis was accepted.

Feeding density of 90g commercial feeds + 20g microalgae paste was found effective in the internal and external characteristics of eggs of DeKalb white layer chickens compared to other rations. It can be concluded that supplementation of a hen diet with the microalgae *Chlorella vulgaris* can therefore be used as a dietary supplement for laying hens.

Recommendations:-

Result of the study on the use of *Chlorella vulgaris* microalgae paste as a supplementary diet for laying hens, was recommended for further study adding more specific parameters in determining the external and internal egg quality to obtain efficient and reliable results.

In terms of feeding density, T2 with 90g commercial feeds + 20g microalgae paste was found effective in the internal and external characteristics of eggs of DeKalb white layer chickens compared to other rations. To clarify effects on laying performance, it is suggested to have a long-term feeding studies using a larger number of laying hens.

Cost of the Microalgae paste in the market is not affordable to local poultry raisers, it is recommended that Microalgae paste producers should develop much affordable algae paste for the local farmers/poultry raisers. It is also necessary to explore cost-effective and sustainable approaches to poultry farming.

Results shows, that different feeding densities and frequencies of the microalgae paste have no significant effects on the external and internal quality of eggs based on the morphological parameters measured. The potential of the microalgae (*C. vulgaris*) paste for poultry farming was explored and challenged current and established feeds used in the poultry farming industry, however, its compatibility and functionality should be studied further for efficient utilization. In order to optimize egg quality especially by the egg producers, the influential factors should be identified. Effective and efficient management should be given for both egg and hen to get high quality product and increase productivity.

References:-

- [1] G.S. Alemayehu. Characterization of scavenging and intensive chicken production and marketing system in Lume District, East Shoa Zone, Oromia Region State, Ethiopia. An MSc. Thesis, Haramaya University, Haramaya, Ethiopia.pp,163, 2017.
- [2] S. Bleakley, M. Hayes. Review Algal Proteins: Extraction, Application and Challenges Concerning Production Foods, 6,33; 2017. doi: 10.3390/foods6050033.
- [3] E. Hanusova, C. Hrnar, A. Hanus, M. Oravcova. Effect of breed on some parameters of egg quality in laying hens. Acta fytotechn zootechny., vol.18, il pp20-24, 2015.
- [4] C.E. Isidahomen, A.A. Njidda, Olatunjia. Egg Quality Traits of Indigenous and Exotic Chicken as Influenced by Specific Genes. Journal of Biology, Agriculture and Healthcare 3 (1):53-58, 2013.
- [5] C.E. Isidahomen, A.A. Njidda, Adenijia. The effects of genotype on internal and external egg quality traits, egg proximate composition and lipid profile characteristics of three strains of layer turkeys. International Journal of Agriculture and Bioscience 3(2):65-69, 2014.
- [6] V. Kotrbacek, M. Skrivan, J. Kopecky, O. Penkava, P. Hudeckova, I. Uhrikova, J. Doubek. Retention of Carotenoids in Egg Yolk of Laying Hens Supplemented with Heterotrophic Chlorella. Czech Journal of Animal Science 58:193-200, 2013.
- [7] H. Mohamed, T.M. Abdel-Hamid. Evaluation the Performance and Egg Quality in Two Strains of Lohmann Classic Breed. Pp.82-91, 2012. Retrieved from <https://www.researchgate.net/publication/313419877>
- [8] A. Molino, A. Lovine, P. Casella, S. Mehariya, S. Chianese, A. Cerbone, D. Musmarra. Microalgae Characterization for Consolidated and New Application in Human Food, Animal Feed and Nutraceuticals. Int. J. Environ. Res. Public Health, 15(11), 2436, 2018. Doi: 10.3390/ijerph15112436
- [9] O.E. Oke, A.O. Ladokun, O.M. Onagbesan. Quality Parameters of Eggs from Chickens Reared in Deep Litter System with or without Access to Grass or Legume Pasture. Livestock Research for Rural Development. 26(11), 2014.
- [10] F.F. Silversides, K. Budgell. The relationships among measures of egg albumen height, pH, and Whipping Volume1. Poultry Science, 83:1619-1623, 2004.
- [11] O.M. Sogunle, A.A. Ayode, A.O. Fafolu, K.O. Bello, D.A. Ekunseitan, K.K. Safiyu, O.J. Odutayo. Evaluation of External and Internal Traits of Eggs from Three Poultry Species at Different Storage Duration in Tropical Environment. Nigerian J. Anim.Sci. 2017, (2):177-189.
- [12] J.L. Zhang, Q.M. Xie, J. Ji, W.H. Yang, Y.B. Wu, J.Y. Ma, Y.Z. Bi. Different combinations of probiotics improved the production performance, egg quality, and immune response of layer hens. Poultry Science 91:2755-2760, 2015.