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Bio-Organic Inputs, Height of Tier and Stocking Density: Their Effects on the Production Performance and Egg Quality of HISEX Layer Chicken

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Abstract

The objective of this study was to examine the impact of using natural bio-organic supplements, varying cage heights, and different stocking densities on the egg-laying performance and egg quality of layer chickens at the Poultry Project for Layer Chicken of JRMSU- Tampilisan Campus in Zamboanga del Norte. The study involved 162 eight-month-old layer chickens divided into six groups and replicated thrice. These chickens were housed in cages of different heights and stocking densities to evaluate their impact on egg production and quality. The results demonstrated that providing chickens with fermented plant juice in their water, derived from madre de agua (Trichanthera gigantea), significantly influenced egg weight and resulted in higher returns above feed and supplement costs. Furthermore, maintaining the cages at a height of 3 feet proved optimal for egg weight. The number of birds in a cage also played a significant role, with four birds per cage affecting egg production and feed and water intake. Interestingly, cages housing three birds exhibited the best feed conversion ratio. Regarding egg quality, the natural supplements did not yield significant differences, but cage height influenced the weight of the eggshells, favoring the 3-foot height. Moreover, the number of birds in a cage impacted the thickness of the yolk. Overall, the study underscored the crucial role of natural supplements, cage height, and stocking density in achieving optimal egg production and quality from layer chickens.

Keywords: Bio-organic inputs, Cage height, Stocking density, Egg production, Egg quality

INTRODUCTION

Poultry raising is the most progressive animal enterprise today. It is one of the world's foremost and fastest producers of meat and eggs, and in the Philippines, it has been a significant contributor to the country's agriculture sector. Currently, the chicken industry shows an increase in production, with 6.99% during the quarter accounting for 16.18% of the entire agricultural output. According to the Philippine Statistics Authority report (Performance of Philippine Agriculture, October- December 2018), poultry production increased by 5.75% from January to December 2018. Despite the level of sophistication it has achieved, the local industry is still facing challenges that deter its further development. One of which is a call for safer and healthier poultry products. Producers must have an alternative. Instead of using antibiotics and other inorganic feeds, they should resort to something else that could imply using organic feeds and supplements. The use of antibiotics as growth promoters for poultry and other animals is discouraged by many experts because of their adverse effects on the animals and the consuming public. Besides, there is a tendency for so-called microbial resistance, a worldwide problem.

Organic agricultural methods are believed to be more environmentally sound than intensive agriculture, which is dependent on the routine use of herbicides, pesticides, and inorganic nutrient applications in the production of crops and animals (Bengtsson et al., 2006). In the Philippines, such promotion of organic farming is articulated in Republic Act No. 10068, otherwise known as "An Act Providing for the Development and Promotion of Organic Agriculture in the Philippines and Other Purposes." Organic agriculture dramatically reduces external inputs by refraining from using chemical fertilizers, pesticides, and pharmaceuticals.

Several studies have used organic supplements as growth promotants for animals, particularly broilers. Lokaewmanee, Yamauchi, and

Thongwittaya (2012), in their study concerning growth performance and carcass characteristics of broilers using fermented plant product (FPP), revealed significant results. This is also affirmed by Casquejo, Casquejo, and Dinoy (2015) in their study about fermented fruit juice given to the broiler as a water supplement. Utilizing different bio-organic inputs as an essential supplement to feed and water is considered part of implementing organic agriculture.

However, in Region IX, particularly in Zamboanga del Norte, studies concerning different bio-organic inputs supplemented to feed and drinking water of chickens have not been established and are only minimal in number. There is a need to address whether such parameters can affect the production performance of layers to eventually give animal raisers, specifically those who are into poultry raising, important baseline information.

Hence, the researchers were prompted to pursue this study to determine if using different bio-organic inputs (Fermented fruit juice, fermented plant juice, and fish amino acid) supplemented in the drinking water can affect the production performance and egg quality of layer (Hisex). In addition, the height of the tier and stocking density were also included in the study as experimental factors to find out if these, too, can affect the production performance and egg quality of the layer.

The study brings significant benefits to the different groups involved. Firstly, local farmers and those involved will find it extremely valuable. It provides them with practical insights into using bio-organic inputs like Fermented Fruit Juice (FFJ), Fermented Plant Juice (FPJ), and Fish Amino Acid (FAA). Additionally, it helps them discover local resources that can be used as alternative water supplements, boosting the organic production of layer chickens. Secondly, the study's findings are crucial for the Department of Agriculture Personnel. They can use this information to make meaningful recommendations and improve the quality of life in rural areas. Lastly, students studying Agriculture will gain hands-on knowledge to complement their classroom learning about organic farming and bio-organic inputs as water supplements, which will benefit their future agricultural endeavors.

The study occurred at the JRMSU-Tampilisan Campus Poultry Site in ZNAC, Tampilisan, Zamboanga del Norte. It aimed to uncover the effects of bioorganic inputs like Fermented Fruit Juice (FFJ), Fermented Plant Juice (FPJ), and Fish Amino Acid (FAA), as well as tier height and stocking density, on the production performance of Hisex layer chickens. The main goal was to understand how these factors impact the chickens' productivity in a real-world setting.

The study aimed to investigate how bio-organic inputs, changes in tier height, and adjustments in stocking density impact the production performance and egg quality of Hisex layer chickens in the specific climate of JRMSU—Tampilisan Campus, ZNAC, Tampilisan, Zamboanga del Norte. Specifically, it assessed the influence of bio-organic inputs like Fermented Fruit Juice (FFJ), Fermented Plant Juice (FPJ), and Fish Amino Acid (FAA) and their combined use on production metrics such as egg quantity, average egg weight, feed consumption, water intake, feed conversion ratio (FCR), and economic feasibility for Hisex chickens. Additionally, the study explored how tier height variations affect layer chicken-production performance when supplemented with bio-organic inputs, focusing on parameters like egg quantity, average egg weight, feed consumption, water intake, FCR, and economic viability. Furthermore, it investigated the impact of changes in stocking density on the production performance of layer chickens with bio-organic inputs, analyzing metrics such as egg quantity, average egg weight, feed consumption, water intake, FCR, and economic feasibility. Moreover, this research evaluated the egg quality of layer chickens with different bio-organic inputs in their water. It also examined the association between tier height, stocking density, and egg quality indicators like yolk thickness, albumin thickness, and eggshell weight. Finally, the study identified and analyzed any significant disparities in the production performance and egg quality of layers concerning the use of bio-organic inputs, variations in tier height, and adjustments in stocking density.

METHODOLOGY

Research Design. The study employed the experimental research design adopting the 6x3 factorial of Randomized Complete Block Design (RCBD). There were 162 heads of eight (8) month layer chicken (hisex) utilized in the study which was divided into six (6) treatments for Bio-organic inputs as Factor A and stocking density as Factor B. Experimental birds were distributed to different cages (24 x 24 x 18 inches) of the same dimension with a stocking density (2, 3 and 4 layers), the different height of tiers of cages (1.5 ft, 3.0 ft and 4.5 ft) served as the block.

Research Environment. The experimental site was at the existing Poultry Project for Layer Chicken production of JRMSU—Tampilisan Campus. It was a 500 sq. meter area with grasses around it. Cages were prepared inside the poultry house. Proper drainage and the availability of water supply were also considered.

Research Treatment. The different treatment combinations utilized in the study were as follows:

T1 - Control (no supplementation) with two layers
T2 - Fermented Fruit Juice (FFJ) with two layers
T3 - Fermented Plant Juice (FPJ) with two layers
T4 - Fish Amino Acid (FAA) with two layers
T5 - Combination of Treatments (FFJ, FPJ, and FAA combined) with two layers
T6 - Antibiotics (positive control) with two layers
T7 - Control (no supplementation) with three layers
T8 - Fermented Fruit Juice (FFJ) with three layers
T9 - Fermented Plant Juice (FPJ) with three layers
T10 - Fish Amino Acid (FAA) with three layers
T11 - Combination of Treatments (FFJ, FPJ, and FAA combined) with three layers
T12 - Antibiotics (positive control) with three layers
T13 - Control (no supplementation) with four layers
T14 - Fermented Fruit Juice (FFJ) with four layers
T15 - Fermented Plant Juice (FPJ) with four layers
T16 - Fish Amino Acid (FAA) with four layers
T17 - Combination of Treatments (FFJ, FPJ, and FAA combined) with four layers
T18 - Antibiotics (positive control) with four layers

Poultry Management Employed

Housing. Inside the 80m2 poultry house, 74 cages made of welded wire were constructed and equipped with feeding and watering pipes. The entire house was adequately cleaned and disinfected before the start of the study to kill possible harmful microorganisms and parasites. As a biosecurity measure, a foot bath was also constructed at the layer house entrance. The entire house was closed using plastic screens to prevent stray animals like dogs, cats, and wild birds from entering.

Care and Management. Experimental birds were monitored daily to check for abnormal conditions and signs of disease. Sanitation around the experimental area was done regularly by removing the feces and applying sawdust below the cages to minimize the odor of bird manure and prevent the build-up of parasites, bacteria, and other microorganisms and flies that could be vectors of pathogens that will eventually cause disease. The provision of light was also observed, especially during the night.

Feeding and provision of water. Commercial layer feed (crumble) was given to the experimental layers daily and divided into two sessions; a ration was given at six (6) o'clock in the morning and four (4) o'clock in the afternoon. Water was made available at all times. The inclusions of different kinds of bio-organic supplements were also replaced daily.

The feeding and watering troughs were cleaned every day.

Preparation of Bio-organic Inputs

Fermented Fruit Juice (FFJ). For Fermented Fruit Juice (FFJ), Dragon Fruit (Hylocereus undatus) was utilized in the study. The fruit, including its peeling, was chopped into small pieces. The chopped fruit was mixed with molasses, which had a ratio of 1:1, and placed in a plastic container covered with manila paper and fermented for ten (10) days or more. After ten (10) days, the fermented fruit juice was harvested. The juice was collected using a strainer and transferred to another container that is ready for use.

Fermented Plant Juice (FPJ). For FPJ, the plant utilized in the study was Madre de Agua (Trichanthera gigantic). The plants' leafy parts were collected early in the morning before sunrise. After that, the same procedure was followed to ferment the plant juice, similar to that of fermented fruit juice.

Fish Amino Acid (FAA). For FAA, Spanish Sardines or Tamban (Sardinelle maderensis) were used in the study. They were adequately chopped into small pieces and followed the same procedure as the fermented fruit juice and plant juice.

Egg collection and weighing. Egg collection and weighing were done daily from three (3) to four (4) o'clock in the afternoon. For proper recording, the collected eggs were placed in the plastic egg trays assigned for the experimental layers' respective treatment, block, and stocking density. All the eggs were weighed using a digital weighing scale. The data gathered were recorded in the production performance record book.

Data Gathered. The following were the data gathered:

1. Production Performance. The different parameters were used to evaluate the production performance of layer chicken (Hisex) supplemented with different kinds of bio-organic inputs in the drinking water and were computed as follows:

   a. Average Eggs produced

   $$AEP = \frac{\text{Actual number of eggs produced}}{\text{Expected number of eggs produced}}$$

   b. Average Weight of eggs

   $$AWE = \frac{\text{Total weight of eggs (g)}}{\text{Total eggs produced}}$$

   c. Total Feed Intake

   $$TFI = \text{Total weight of feed given} - \text{Total weight of feed remain}$$

   d. Total Water Intake

   $$TWI = \text{Total water (ml) given} - \text{Total water (ml) remain}$$

   e. Feed Conversion Ratio

   $$FCR = \frac{\text{Total weight of feed consumed (g)}}{\text{Total weight of eggs produced (g)}}$$

   f. Return above feed and supplement cost

   $$RFSC = \text{Total sale of eggs} - \text{Total feed and supplement cost}$$

2. Egg Quality. The representative egg was randomly selected from each treatment for egg quality evaluation. The egg was broken fresh, and the shell, egg yolk, and albumin were separated for evaluation. The parameters evaluated were as follows:

   a. Thickness of yolk. The egg yolk was placed in a bowl with a flat bottom two (2) inches in diameter, and the egg yolk thickness was measured using a ruler in the unit millimeters (mm).

   b. Thickness of Albumin. The albumin of the egg was placed in a bowl with a flat bottom two (2) inches in diameter, and the albumin thickness was measured using a ruler in the unit millimeters (mm).

3. Eggshell Weight. The egg's shell was measured in terms of its weight in grams (g). It was weighed using a weighing scale with a 100-gram (g) precision.

4. Photographic Recordings. Pictures were taken of the following:
   a. Preparation of the cages, feeding trough, waterer, and the experimental layer chicken.
   b. Preparation of bio-organics inputs
   c. Collection and sizing of eggs

Statistical Treatment. All the data gathered were analyzed using the variance analysis (ANOVA) of the randomized complete block design (RCBD) to determine whether the results were significant. Significant differences among treatment means were analyzed using the Tukey—Kramer HSD test to determine differences between treatments.

Ethical Considerations. No human subjects were asked to participate in this study. Only chickens used the area, so only the letter to the Campus Administration was given. With permission granted, the study was completed.

RESULTS AND DISCUSSION

Bio-organic inputs and production performance. Table 1 presents the effects of bioorganic inputs on the production performance of layers. As reflected in the table, all the parameters in the production performance showed insignificant effects, except for the average weight of eggs and return above feed and supplement cost, which is significant.

Table 1
Production Performance of Layers supplemented with different bio-organic inputs

Treatments	Number of Eggs produced	Ave. weight of Eggs (g)	Feed Intake (g)	Water Intake (ml)	Feed Conversion Ratio (FCR)	Return above Feed And Supplement Cost (RFSC) in Peso
T_1 - no supplementation	152.56	58.19^{b}	18033.4	56079.1	1.96	237.02^{ab}
T_2 - fermented fruit juice (FFJ)	156.00	58.24^{b}	18314.8	59386.6	1.80	175.65^{b}
T_3 - fermented plant juice (FPJ)	162.89	67.12^{a}	17996.6	57016.7	1.82	298.95^{a}
T_4 - fish amino acid (FAA)	156.22	57.95^{b}	18151.9	55589.6	1.88	230.43^{ab}
T_5 - combination of FFJ, FPJ and FAA	157.67	58.33^{b}	17563.8	53940.2	1.81	257.66^{ab}
T_6 – antibiotic	159.22	68.94^{a}	18154.1	54826.1	1.83	166.15^{b}
F-test	ns	**	Ns	ns	ns	**
CV	5.7%	9.6%	2.1%	5.6%	8.2%	13.5%

Different bioorganic inputs significantly affected the average weight of eggs produced and the returns above feed and supplement cost (RFSC) as statistically treated. In terms of the average weight of eggs, among the treatments understudied, T6 (Antibiotic) got the highest mean, followed by T3 (Fermented Plant Juice), T5 (Combination of FFJ, FPJ, and FAA), T2 (Fermented Fruit Juice), T1 (no supplementation) and T4 (Fish Amino Acid).

Nonetheless, regarding bio-organic inputs, T3 (Fermented Plant Juice) got the highest mean, and the result was comparable to that of antibiotics. The significant result on the production performance of layers, particularly on the egg's weight, in favor of T6 (Antibiotic), can be attributed to antibiotics promoting animal growth, thereby affecting the weight of eggs of layers. However, using antibiotics as growth enhancers increases the proportion of resistant bacteria.

Dipeolu et al. (2005) affirmed the above findings, they emphasized that the egg quality in terms of egg weight is highest in the hens given diets containing either enzyme alone or antibiotic. On the contrary, Rahman et al. (2016) stated that antibiotics significantly differed in egg production, especially in mortality, but had no significant effect on feed conversion efficiency and egg weight.

On the other hand, the comparative result is observed between T6 (antibiotic) and T3 (Fermented Plant Juice) concerning its effect on the egg weight of layers. The effect of T3 on the egg weight layer can be attributed to the nutritive value of the plant madre de agua (Trichanthera gigantea), which contains balanced amino acids, high crude protein, and does not have anti-nutritional factors, which in turn produces more giant eggs. Delacruz (2015), in her article published in the Phil. Star mentioned that the Trichanthera plant has crude protein, fiber, calcium, and phosphorous and is a good feed source. Further, she cited that the leaves of Trichanthera are good sources of proteins for poultry and livestock, and they are a cheap feed source for raising animals.
In the study conducted by Sarwatt (2003), they affirmed that including Trichanthera gigantea in the diets significantly increased daily average DM intake, protein intake, growth rate, and carcass weight relative to the control. The crude protein and fiber contents of Trichanthera

gigantea were 23.9 and 23.8% in dry matter (DM), respectively.

Another parameter that yielded significant results as treated statistically for bio-organic supplements is the Return above Feed and Supplement Cost (RFSC) (Table 1.0). As the table shows, the highest RFSC is on the layers supplemented with fermented plant juice in the drinking water (T3). Such a significant result is attributed to the supplement cost, considering that T3 had the cheapest expenses compared to the rest of the treatments, whereby the supplements are costly or more expensive. Suwanpanya et al. (2011) studied the effect of biologically fermented plant juice and probiotics. Results showed that biologically fermented plant juice has higher economic income. Moreover, Dela Cruz (2015) states that the leaves of Trichanthera are good sources of proteins for poultry and livestock, and they are a cheap feed source for raising animals. In addition, Nhan et al. (1997) affirmed that the cost of production tended to be lower for diets with Trichanthera leaf meal.

This implies that the use of Fermented Plant Juice, particularly Trichanthera, is beneficial as a supplement in the drinking water for layers since it significantly affects the weight of eggs, which will lead to higher income, considering that Fermented Plant Juice has a lower production cost compared with the other supplements.

Height of tier and production performance. Table 2 reflects the effects of tier height on layer production performance, significantly affecting egg average weight.

Table 2

Production Performance of Layers under different tier height

Height of Tier (Ft.)	Number of Eggs produced	Ave. weight of Eggs (g)	Feed Intake (g)	Water Intake (ml)	Feed Conversion Ratio (FCR)	Return above Feed and Supplement Cost (RFSC) in Peso
1.5	157.27	58.10^{b}	18246.06	56638.50	1.86	208.77
3.0	158.00	64.58^{a}	18174.44	55929.50	1.73	256.49
4.5	157.00	61.73^{ab}	17686.80	55851.11	1.91	217.67
F- test	ns	*	ns	ns	ns	Ns
CV	27.8%	11.4%	30.3%	30.8%	9.6%	41.3%

As can be gleaned from the above table, the height of the tier significantly affected the average weight of eggs produced by layers. A tier height of 3 feet produced the highest average weight of eggs, followed by a tier height of 4.5, and a tier height of 1.5 produced the most negligible average egg weight.

This could be attributed to the inherent characteristics of chicken dung to release ammonia, a kind of gas that has some adverse effects on animals. Those closer to the accumulated chicken dung may have a bigger chance of inhaling the ammonia. On the other hand, the birds in the higher tier had a bigger chance to experience the heat from the roof of the layer house, especially during hot weather conditions, as the case for the tier height of 4.5 feet from the ground, which is closer to the roof of the layer house. In changing weather conditions like hot and cold weather, the layer chicken with a height of 4.5 feet is most likely to experience environmental stress compared to the other. Thus, the tier height of 3 feet, being in the middle of tier 1.5 feet and 4.5 feet, is not so directly exposed to these environmental problems, and with such, layers have experienced lesser stress that will affect their performance.

Such findings were also supported by the study of Garner et al. (2012), who affirmed that eggs/hen-housed increased with greater feeder space allocation and taller cages. The case weight of eggs was more significant with increasing cage floor slope; in cages, drinkers were placed more toward the front or back of the cage than in the middle, with more space/hen and with higher caloric intake. In addition, taller cages increased hen-housed eggs. Hens in taller cages can stand more erect, which probably leads to increased performance of comfort behaviors.

This was supported by Dawkins (1985) and Nicol (1987), as cited by Garner (2012), who mentioned that taller cages increased hen-housed egg production. Garner et al. (2012) affirmed that results reveal essential effects of feeder space, floor space, and cage height.

This implies that the height of the tier is an essential factor to consider in raising layers, considering that such can affect the production performance of layers, specifically, the average weight of eggs. Based on this study, regarding tier heights' effect on the average weight of eggs, a tiered height of 3 feet from the ground in the middle gave better production performance.

Stocking density and production performance. Table 3 presents the effect of stocking density on a layer's production performance. The result significantly affects the number of eggs produced except for the average weight and returns above feed and supplement cost.

Table 3

Production Performance of Layers under Different Stocking Density

Stocking Density (Layers per cage)	Number of Eggs produced	Ave. weight of Eggs (g)	Feed Intake (g)	Water Intake (ml)	Feed Conversion Ratio (FCR)	Return above Feed and Supplement Cost (RFSC) in Peso
2	105.111^{c}	61.13	11559.20^{c}	35663.30^{c}	1.86^{b}	208.77
3	160.056^{b}	61.66	18176.90^{b}	56633.40^{b}	1.78^{ab}	256.49
4	207.111^{a}	61.62	24371.20^{a}	76122.30^{a}	1.91^{a}	217.67
F-test	*	ns	*	*	*	ns
CV (%)	5.7	9.7	6.2	5.7	8.3	29.3

As revealed, the highest number of eggs produced is from the layers of four (4) birds in a cage, followed by three (3) birds in a cage, and lastly, from a stocking density of two (2) layers in a cage. The same applies to feed and water intake and its feed conversion ratio. This means stocking density affects the number of eggs chickens produce in the layer. It implies that the more layers there are in a cage, the higher the number of eggs produced. This means that the stocking of two (2) birds in a cage is not comparable to the eggs produced by three (3) birds in a cage, nor can it be compared to layers of four (4) stocking density.

Regarding feed intake, the highest feed intake was observed by layers of four (4) stocking density, followed by layers of three (3) stocking density and layers of two (2) stocking density. As to water intake, the highest water intake was consumed by layers of four (4) stocking density, followed by three (3) and layers of two (2) stocking density. This means that the more layers in a cage, the more the feed and water intake. Regarding feed conversion ratio, the highest (poorer) feed conversion ratio was obtained by layers of four (4) stocking densities. This was followed by a stocking density of two (2), and the lowest (better) was observed in the stocking density of three (3). This implies that in terms of feed conversion ratio, three chickens in a cage are a more efficient feed converter than 2 and 4 chickens in a cage.

Benyi et al.'s (2006) study confirms the above findings. As revealed in their study, housing birds 2 or 3 per cage resulted in more significant body weight gain, higher egg production, heavier eggs, a better feed conversion ratio, and lower mortality than housing those 4 per cage. Significant interactions existed between strain and stocking density for egg production, weight, output, and mortality.

Bio-organic inputs and egg quality. Table 4-A presents the egg quality of layers supplemented with different bio-organic inputs. As shown in the table, no significant effect was noted among treatments.

Table 4-A

Egg Quality of Layers supplemented with different bio-organic inputs

Treatments	Thickness of the yolk (mm)	Thickness of the albumin (mm)	Weight of the shell (g)
T_1 - no supplementation	8.63	12.96	6.74
T_2 - fermented fruit juice (FFJ)	8.55	12.99	6.74
T_3 - fermented plant juice (FPJ)	8.59	12.70	6.81
T_4 - fish amino acid (FAA)	8.63	12.99	6.77
T_5 - combination of FFJ, FPJ and FAA	8.21	12.14	7.21
T_6 - antibiotic	8.37	12.69	6.88
sF-test	ns	ns	ns
CV	4.8%	5.5%	13.7%

The table above shows the effect of bio-organic supplements on the egg quality of layers. No significant differences were noted among treatments, which means that using different bio-organic supplements did not significantly affect the quality of eggs produced by layers.

Egg quality and height of tier. Table 4-B shows the effect of different tier heights on the egg quality of layers. As reflected in the table, among the parameters of the egg quality being studied, a significant effect was observed only on the weight of the shell.

Table 4-B

Egg Quality of layers under different tier height

Height of Tier (Ft)	Thickness of the yolk (mm)	Thickness of the albumin (mm)	Weight of the shell (g)
1.5	8.58	12.81	6.79[ab]
3.0	8.49	12.98	7.11[a]
4.5	8.48	12.96	6.68[b]
F-test	Ns	Ns	*
CV (%)	1.18	1.16	1.17

The highest weighted mean was obtained by height of 3 feet, followed by tier height of 1.5 and 4.5 feet. The significant result in favor of a tier height of 3 feet can be attributed to environmental conditions where the tier height of 3 feet is located in the middle tier, whereby the chicken was not directly exposed to the ammonia gas produced from the accumulated chicken dung, unlike the tier height of 1.5 ft. which is very close to the ground. On the other hand, a tier height of 4.5, which was also very close to the roof of the layer house, has a higher chance of being exposed to the heat from the roofing during the hot season. In other words, the layer chicken in the tier, which has a height of 3 feet, is located in the middle and experiences lesser stress compared to the layer cage in the tier, which has a height of 1.5 and 4.5 feet.

The study of Lopes et al. (2010) supports the findings of this study as they stated that egg quality is greatly influenced by hen physiology, including age, molt, and environmental conditions (temperature, lighting cycle, and rearing system). Accordingly, high ambient temperature (> 30°C) elicits changes in acid-basic balance and feed consumption in hens, and these changes reduce egg production, egg weight, and eggshell strength. Lighting programs applied during the rearing and production periods of hen's influence egg production.

This implies that tier height should be considered when making housing for layers as it will affect the egg quality produced by the layer chicken.

Egg quality and stocking density. Table 4-C shows the effect of different stocking densities on the egg quality of layers. As reflected in the table, among the parameters of the egg quality being studied, a significant effect was observed on the thickness of the yolk.

Table 4-C

Egg Quality of layers under different stocking density

Stocking Density (layers/cage)	Thickness of the Yolk (mm)	Thickness of the Albumin (mm)	Weight of the shell (g)
2	8.26[b]	12.81	6.68
3	8.64[a]	13.13	6.90
4	8.57[ab]	12.81	7.00
F-test	*	ns	Ns
CV (%)	1.7	1.6	2.1

The result shows that in terms of the yolk thickness, the highest was obtained by the layers caged in a stocking density of 4, followed by 3, and the lowest was obtained by birds caged in a stocking density of 2 in a cage.

The significant result is attributed to environmental conditions, particularly the number of chickens in a cage to space. Stocking four birds in a 30x30-inch cage may create a stressful condition that makes it difficult for them to move. It also contributes to the hot conditions, eventually affecting the bird's behavior. Such a stressful condition can affect the early development of the egg.

On the other hand, two birds stocked in a cage with a 30x30-inch floor space are spacious, meaning the birds have more space to move around. This implies that birds utilize more energy if space is more significant. However, a bigger bird space in a cage is unfavorable during cold weather conditions.

Furgasa, Yimer, Tamiru, and Duguma (2019) stated that the type of production system may influence eggshell quality. For example, eggshell thickness varies according to housing systems, which influence the behavior of hens, especially when hens in cages and non-cage systems are compared. The space allotted for non-cage systems will give hens more energy for movement, which may result in smaller eggs or reduced yolk content.

Production performance under different bio-organic inputs. Table 5-A is the analysis of variance (ANOVA) for production performance as affected by different bio-organic inputs. The table shows a significant difference between the bio-organic supplements and the average weight of eggs.

Table 5-A

One-way analysis of Variance on the production performance of layers affected by different bio-organic inputs

	Source	DF	SS	MS	F	P
No. of eggs Produced	Treatment	5	542.98	108.60	0.0514	0.99
	Replication	2	9.59	4.80	0.0023	0.99
	Error	46	97194.63	2112.93		
	C. Total	53	97747.20			
Ave. weight of Eggs produced	Treatment	5	1177.39	235.47	7.98	0001**
	Replication	2	380.23	190.12	6.44	0.0034*
	Error	46	1357.01	29.50		
	C. Total	53	2914.64			
Feed Intake (g)	Treatment	5	2966796.28	593359.26	0.02	0.99
	Replication	2	3334110.32	1667055.20	0.05	0.95
	Error	46	1525573550.00	33164642.00		
	C. Total	53	1531874457.00			
Water Intake (ml)	Treatment	5	163626207.00	32725241.00	0.09	0.99
	Replication	2	677284.48	3386421.20	0.01	0.98
	Error	46	1.511e+10	328472633.00		
	C. Total	53	1.528e+10			
Feed Conversion Ratio (FCR)	Treatment	5	0.18	0.04	1.15	0.34
	Replication	2	0.15	0.08	2.42	0.10
	Error	46	1.44	0.03		
	C. Total	53	1.78			
Return above Feed and Supplement Cost	Treatment	5	113094.51	22618.90	3.07	0.01*
	Replication	2	23147.74	11587.40	1.57	0.21
	Error	46	338512.36	7359.00		
	C. Total	53	474781.61			

The significant difference between the bio-organic supplements and the average weight of eggs is reflected by its computed p-value of .0001, which is lower than the 0.05 significance level. The same is true with bio-organic supplements returning above feed and supplement cost (RFSC) with a 0.01 computed p-value.

With the result above, it can be stated that there is a significant difference between bio-organic inputs and the production performance of the layer, particularly on the average weight of eggs and return above feed and supplement cost. Therefore, the null hypothesis stating that there is no significant difference between bio-organic inputs and the production performance of the layer is rejected. Among treatments, T3 (fermented plant juice) produced heavier eggs and obtained the highest return above feed and supplement costs.

Production performance of layers under different tier height. Table 5-B is the analysis of variance (ANOVA) for production performance as affected by tier height. As reflected, there is no significant difference between tier height and production performance except for the average weight of eggs.

Table 5-B

One-way Analysis of Variance on the production performance of layers under different tier height

	Source	*DF*	*SS*	*MS*	*F*	*P*
No. of eggs Produced	Height	2	9.59	4.80	0.0025	0.99
	Error	51	97737.61	1916.42		
	C. Total	53	97747.20			
Ave. weight of Eggs produced	Height	2	380.23	190.12	3.82	0.03*
	Error	51	2534.40	49.69		
	C. Total	53	2914.64			
Feed Intake (g)	Height	2	3334110.32	1667055.20	0.055	0.94
	Error	51	1528540347.00	29971379.00		
	C. Total	53	1531874457.00			
Water Intake (ml)	Height	2	6772842.48	3386421.20	0.011	0.98
	Error	51	1.5273e+10	299477790.00		
	C. Total	53	1.528e+10			
Feed Conversion Ratio (FCR)	Height	2	0.15	0.07	2.38	1.10
	Error	51	0.62	0.03		
	C. Total	53	1.78			
Return above Feed and Supplement Cost	Height	2	23174.74	11587.40	1.30	0.27
	Error	51	4521606.88	8855.00		
	C. Total	53	474781.61			

The result is manifested by its computed p-values of .99 for the number of eggs produced, .94 for feed intake, .98 for water intake feed, 1.10 for feed conversion ratio, and .27 for return above feed and supplement cost (RFSC), which are all higher than the 0.05 level of significance interpreted as insignificant.

On the other hand, a significant difference between the height of the tier and the average weight of the egg was evident with its computed p-value of 0.03, which is lower than the 0.05 level of significance interpreted as significant.

Therefore, the null hypothesis stating that there is no significant difference between the height of the tier and the production performance of the layer (chicken) is rejected. Among the different heights of tiers, the three (3) feet tall produced the heaviest eggs.

Production performance of layers under different stocking density. Table 5-C above is the analysis of variance (ANOVA) for production performance as affected by stocking density. As reflected, there is a significant difference between the stocking density and production performance except on the average weight of eggs and return above feed and supplement cost.

Table 5-C
One-way Analysis of Variance on the production performance of layers under different stocking density

	Source	DF	SS	MS	F	P
No. of eggs Produced	Stock density	2	93822.70	46911.40	587.15	.0001**
	Replication	2	9.59	4.80	0.06	0.94
	Error	49	3914.90	79.90		
	C. Total	53	97747.20			
Ave. weight of Eggs produced	Stock density	2	3.16	1.58	0.03	0.97
	Replication	2	380.24	190.00.	3.68	0.03*
	Error	49	2531.24	119.00		
	C. Total	53	2914.64.15			
Feed Intake (g)	Stock density	2	1477858336.0	738929168.00	714.41	.0001**
	Replication	2	33341110.32	1667055.20	1.61	0.20
	Error	49	50682011.30	1034326.80		
	C. Total	53	1531874457.00			
Water Intake (ml)	Stock density	2	1.4739e+10	7.3695e+10	675.71	.0001**
	Replication	2	6772842.48	3366421.20	0.31	0.73
	Error	49	534409128	10906309.00		
	C. Total	53	1.528e+10			
Feed Conversion Ratio (FCR)	Stock density	2	0.08	0.04	4.3902	0.02*
	Replication	2	0.078	0.04	4.2081	0.02
	Error	49	0.45	0.01		
	C. Total	53	0.61			
Return above Feed and Supplement Cost	Stock density	2	137.49	68.74	0.42	0.65
	Replication	2	1032.45	516.22	3.21	0.21
	Error	49	7877.13	160.75		
	C. Total	53	9047.09			

Table 5-C above is the analysis of variance (ANOVA) for production performance as affected by stocking density. As reflected, there is a significant difference between the stocking density and production performance except for the average weight of eggs and return above feed and supplement cost. This is reflected by the computed p-values of 0.001 for the number of eggs produced, 0.001 both for water and feed intake and 0.02 for feed conversion, which are all lower than the 0.05 significance level, implying a significant result.

This implies that the null hypothesis of no significant difference between stocking density and layer (chicken) production performance is rejected. Among the stocking densities with 2, 3, and 4 layers confined per cage, 4 layers housed in a cage produced the most eggs.

Conclusion. Supplementing different bio-organic inputs in the drinking water of layer chickens (Hisex), particularly fermented plant juice using Trichanthera can significantly improve the weight of eggs, the feed and water intake of birds, and the Returns Above Feed and Supplement Cost.

The three (3) feet tier height significantly improved the eggs' average weight and the shell's thickness. In contrast, the stocking density of 4 birds per cage significantly improved the number of eggs produced, feed intake, water intake, feed conversion ratio, and the thickness of the yolk.

Recommendations. Based on the findings, the following recommendations are hereby forwarded:

1. Farmers are encouraged to use Fermented Madre de Agua (Trichanthera gigantea) as a supplement to the drinking water of layer chickens (Hisex) since it has significantly improved the weight of eggs and yielded higher returns above feed and supplement cost.
2. Farmers may consider a tiered height 3 feet above the ground for a higher egg weight and a thick eggshell.
3. It is also recommended that a stocking density of 4 layers per cage be considered for better production performance and 3 layers per cage for the thickness of the yolk.
4. Future researchers are encouraged to verify the study's findings at the village or farmer level, using them as baseline information.

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REFERENCES

Asghedom, N., Kjosn, N., & Austbo, D. (2006). Effect of Fishmeal Supplementation on Egg Production of Rhode Island Red Layers in Eritrea. Tanzania. Journal of Agricultural Science, 7.

Barreto, N. B., Coelho, S. M. D., Coelho, I. S., & Souza, M. M. S. (2017). Characterization of Virulence & Antibiotic Profile Agr Typing of Staphylococcus Aureus from Milk of Subclinical Mastitis Bovine in State of Rio de Janeiro. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 69(4). http://dx.doi.org/10.1590/1678-4162-9260

Benyi, K., Norris, D., & Tsatsinyane, P. M. (2006). Effects of stocking density and group size on the performance of white and brown Hyline layers in semi-arid conditions. Tropical Animal Health and Production, 38(7–8), 619–624.

Bengtsson, J., Weibull, C., & Ahnstrom, J. (2005). The effects of organic agriculture on biodiversity and abundance: A meta-analysis. Journal of Applied Ecology, 42(2), 261–269.

Casquejo, J. S., Casquejo, J. S., & Dinoy, R. R. (2015). Fermented Plant Juice: Its Effect on the Growth Performance of Broiler. Retrieved from http://www.woto.com

Dawkins, M. S. (1985). Cage height preference and use in battery-kept hens. Veterinary Records, 116, 345–347.

Dela Cruz, R. T. (June 7, 2015). Trichantera: A Cheap Feed Source for Organic Native Pig Production. The Philippine Star.

Dipeolu, M. A., Eruvbetine, D., Oguntona, E. B., Bankole, O. O., & Sowunmi, K. S. (2006). Comparison of Effects of Antibiotics and Enzyme Inclusion in Diets of Laying Birds. College of Animal Science and Livestock Production. Abeokuta: University of Agriculture.

FAO. (2006). Livestock's long shadow: Environmental issues and options. Retrieved from http://www.virtualcentre.org/en/library/key_pub/longshad/a0701e/A0701E00.pdf.

Fidan, E. D., Turkyilmaz, M. K., & Nazligul, A. (2012). The Effects of Different Storage and Fumigation Lengths on Hatchability and Hatching Weight in Japanese Quails (Coturnix, Coturnix japonica). Journal of Animal and Veterinary Advances, 11, 1400–1404.

Furgasa, W., Tamiru, H., Duguma, M., & Yimer, L. (2019). Review on Chicken Egg Quality Determination, Grading and Affecting factors. Retrieved from http://ajmsrr.com/index.php/ajmsrr/01/Issue 01

Garner, J. P., Kiess, A. S., Mench, J. A., Newberry, R. C., & Hester, P. Y. The effect of cage and house design on egg production and egg weight of White Leghorn hens: An epidemiological study. Poultry Science, 91(7), 1522–1535. Retrieved from: https://doi.org/10.3382/ps.2011-01969

Philippine R.A. NO. 10068. Organic Agriculture Act of 2010. Retrieved from https://www.officialgazette.gov.ph./2010/04/06/republic act no-10068

Guo, Z. G., Song, H. C., Jiao, Q., Song, Q., & Lin, H. (2012). The effect of group size and stocking density on the welfare and performance of hens housed in furnished cages during summer. Universities Federation for Animal Welfare, 21, 41–49.

Hadi, N., Mohamad, M., Robin, M., & Yusof, R. (2012). Effects of Red Pitaya Fruit (Hylocereus Polyrhizus) Consumption on Blood Glucose Level & Lipid Profile in Type 2 Diabetic Subjects. Borneo Science, 31.

Kang, H. K., Park, S. B., Kim, S. H., & Kim, C. H. (2016). Effects of stock density on the laying performance, blood parameter, corticosterone, litter quality, gas emission, and bone mineral density of laying hens in floor pens. Poultry Science, 95(12), 2764–2770. Retrieved from: https://doi.org/10.3382/ps/pew264

Lambio, A. L. (2010). Trends and Opportunities in Organic Poultry Production. Animal Breeding and Physiology Division. Retrieved from http://www.uplb.edu.ph.

Lokaewmanee, K., Yamauchi, K., & Thongwittaya, N. (2012). Effects of fermented plant product on growth performance, some blood variables, carcass characteristics, and intestinal histology in broilers. Laboratory of Animal Science, Faculty of Agriculture. Japan: Kagawa University.

Lopes, E., Nys, Y., & Travel, A. (2010). Physiological and environmental factors affecting egg Quality. Productions Animales -Paris- Institut National de la Recherche Agronomique-23(2), 155-166.

Mottet, A., & Tempio, G. (2017). Global poultry production: current state and future outlook and challenges. World's Poultry Science Journal, 73(2), 245-246. Retrieved from https://doi.org/10.1017/soo43933917000071

Nhan, N. T. H., Preston, T. R., & Dolberg, F. (1997). Use of Trichantera gigantea leaf meal and fresh leaves as livestock feed. Livestock Research for Rural Development, 9(7). Retrieved from: http://www.lrrd.org./lrrd9.htm

Philippine Statistics Authority (2019). Report on Performance of Philippine Agriculture. October-December 2018. Retrieved from https://psa.gov.ph/ppa-main/livestock-poultry

Polito, W. L. (2006). The Trofobiose Theory and organic agriculture: The active mobilization of nutrients and using rock powder as a tool for sustainability. Anais da Academia Brasileira de Ciencias, 78(4), 765-79.

Rahman, Md., Khalaydur, Md., Majumder, K. H., Ali, Y., Most. Khatun, M., Kabir, … & Sultana, F. (2016). Antibiotic use to the production performance of ISA brown layer. Asian Journal of Medical and Biological Research, 2(4). DOI: 10.3329/ajmbr.v2i4.30994

Sarica, M., Boga, S., & Yamak, U. S. (2008). The effects of space allowance on egg yield, egg quality, and plumage condition of laying hens in battery cages. Czech Journal for Animal Science, 53(8), 346–353.

Sarwatt, S. V. G., Laswai, H., & Ubwe, R. (2003). Evaluation of the potential of Trichanthera gigantea as a source of nutrients for rabbit diets under small-holder production system Tanzania. Livestock Research for Rural Development, 15(11).

Sekeroglu, A., Duman, M., Tahtali, Y., Yildirimi, A., & Eleroglu, H. (2014). Effect of cage tier and age on performance, egg quality, and stress parameters of laying hens. South African Journal of Animal Science, 44(3).

Suwanpanya, N., Ponpri, C., & Kongsut, C. (2011). Effect of biological fermented plant juice mixed in concentrate feed on production performance in organic dairy cows. Strategies and Challenges for Sustainable Animal Agriculture-Crop Systems (SAADC), VIII. Retrieved from https://www.cabdirect.org/cabdirect/abstract/20113387068.