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LAYING PERFORMANCE AND EGG QUALITY OF UPGRADED LAYER FED WITH DIFFERENT LEVELS OF ANNATTO SEEDS (*Bixa orellana L.*) AS FEED SUPPLEMENT RAISED UNDER DIFFERENT HOUSING CONDITIONS

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Abstract. This study was conducted to determine the laying performance and egg quality of upgraded layer fed with different levels of annatto seeds as feed supplement under different housing conditions. The experimental method of research using Complete Randomized Design with four treatments in three replications was employed. The data gathered on the different levels of annatto seeds as feed supplement and the different housing conditions for the laying performance and egg quality were analyzed using Analysis of Variance and Duncan Multiple Range Test. The findings implied that the laying performance of upgraded layer was significantly affected by different levels of annatto seeds as feed supplement and has comparable effect on length, color, and weight of yolk but the weight, width, weight of albumen and color of yolk were significantly affected. The housing condition did not affect the laying performance and egg quality of the upgraded layer.
Keywords: Annatto seeds, egg quality, housing, laying performance, supplement

1. Introduction

Background of the Study

Keeping poultry makes a substantial contribution to the household food security, economy of the province and the country in general. It helps diversify income and provides quality food, energy, fertilizer and a renewable asset in over 80 percent of rural household. It also provides a major income -generating activity for the household from the sale of birds and eggs, as well as a valuable source of protein in the diet.

According to William, (2004) over 90% of the fresh table eggs consumed are produced commercially by local poultry raisers in the country. Preliminary estimates suggest that farmers produce 25,000,000 dozen eggs valued at around million per annum (1 m/ doz.). However, because of the very little fresh eggs imported into or traded within the region the demand of food manufacturers and tourist industries importation of processed egg products are resorted to by restaurant and other business owners. The implementation of strategies to improve the nutritional composition and quality of animal food products has recently emerged as an interface of animal science, food science and human nutrition.

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

Annatto is a natural carotenoid obtained from Bixa orellana shrub. The seeds are gaining economic importance in recent years as highly desirable colorants. The ripe fruit of annatto on drying yield annatto seed serves as the raw material for the production of annatto color.

According to Preston and Rickard, (1980) they stated that annatto seeds contain high levels of the carotenoids bixin and norbixin, and their ratio varies with a general predominance of bixin. On the other hand, Braz (2007) explained that bixin is non-toxic and can be extracted from the seed pulp having several applications in human foods and animal feed while norbixin is usually present in small amounts in the seeds. Melendez-Martinez *et al*., (2004) revealed that, the inclusion of annatto in animal feeds are based on the utilization of its by product and oil extracts that are obtained from seeds to maintain productivity and to improve egg yolk and broiler skin and meat color.

On the other hand Jacob *et al*., (2000), mentioned that the colour of the egg shell is determined primarily by the genetics of the hen, where white feathered hens laying white eggs shell and brown feathered hens laying brown egg with brown eggshell.

The use of conventional caging improves the opportunity to monitor individual birds health and well-being. The house is intended to accommodate number of layers divided into compartments one area is intended for the cage and the other is for the litter space. In some cases the laying performance of a layer depends in their body weight .Smaller birds at peak or shortly following their peak in egg production often do not have the physical capacity to consume enough feed to provide adequate energy and will be forced to rely on body stores.

Since the significance of annatto seeds and different housing conditions in poultry products properly justified the need to further assess its effects on the experimental birds is deemed necessary to further generate important ideas and information that will be useful to poultry raisers not only in the local area but also among commercial poultry raisers.

This study provides information and factual data to the local farmers, poultry raisers, feed manufacturer, businessmen, agriculture students, faculty, community and other researchers to know the significant uses of annatto seeds as fed supplement to improve the laying performance and egg quality of upgraded layers.

The study aimed to determine the laying performance and egg quality of upgraded layers fed with different levels of annatto seeds as feed supplement under different housing conditions. Specifically, the objectives were to identify the differences on the effects housing conditions and different levels of annatto seeds as feed supplement on the laying performance and egg quality of upgraded layers, which level of annatto seeds and housing conditions produce significantly higher egg production and quality, and the interaction effect between the levels of annatto seeds and different housing condition.

2. Methodology

The experimental method of research was used in the study to determine the laying performance and egg quality fed with different levels of annatto seeds raised under different housing conditions. The Completely Randomized Design with four treatments and three replications was used on the experimental procedure.

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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Experimental Layout

Figure 1. Experimental Layout -Conventional on litter floor cages

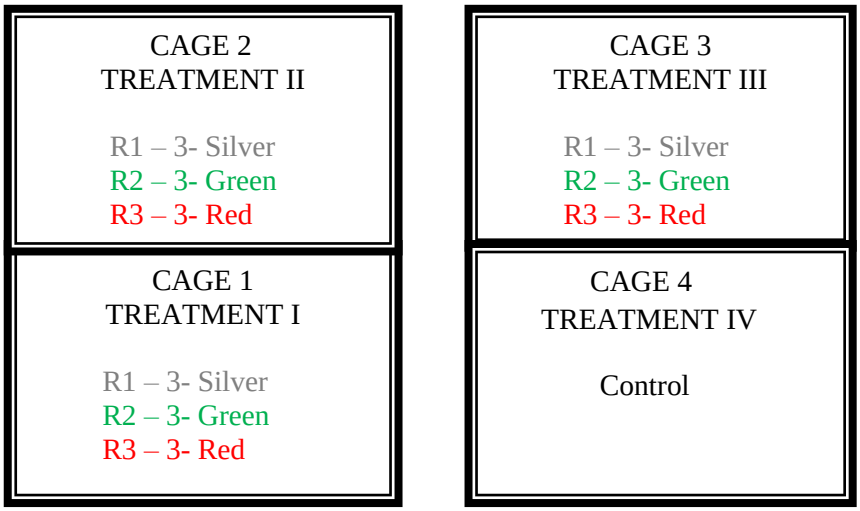

Figure 2. Distribution of layer by treatments and replications in conventional litter housing.

HOUSING 1	Levels of Annatto Seeds	REPLICATIONS			
		I	II	III	Total
Conventional litter floor housing	TI-L1 100 + 900g laying mash	Silver R1-3	Green R2-3	Red R3-3	9
	TII-L2 150g + 850g laying mash	R1-3	R2-3	R3-3	9
	TIII-L3 200g+ 800g laying mash	R1-3	R2-3	R3-3	9
	TIV-L4 control 1000g laying mash	R1-3	R2-3	R3-3	9
TOTAL		12	12	12	36heads

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

Figure 3.Experimental Layout on Stair-step Housing

First step cage	1st Level 9 heads	T I	100 grams annatto seeds plus 900 grams commercial laying mash
Second step cage	2nd Level with 9 heads	TII	150 grams annatto seeds plus 850 grams commercial laying mash
Third step cage	3rd Level with 9 heads	TIII	200 grams annatto seeds plus 800 grams commercial laying mash
Fourth step cage	4th Level with 9 heads	TIV Control	1000 grams commercial laying mash

Figure 4. Distribution of layer by treatments and replications in stair-step housing

HOUSING 2	Levels of Annatto Seeds	REPLICATIONS			Total
		I	II	III	
Stair-step housing	TI-L1 100g+900g laying mash	R1-3	R2-3	R3-3	9
	TII-L2 150g+ 850g laying mash	R1-3	R2-3	R3-3	9
	TIII-L3200g+ 800g laying mash	R1-3	R2-3	R3-3	9
	TIV-L4 control 1000g laying mash	R1-3	R2-3	R3-3	9
TOTAL		12	12	12	36heads

Types of Housing

The available poultry houses at the Romblon State University, College of Agriculture Area were used for the experiment which was divided into two types of housing. Housing 1 conventional litter floor and housing 2 was the stair-step cage. The area for conventional cages measured 80 square meters; while each cage has a floor area of 5ft in length and 4ft width furnished. This cage was with nest made of plywood and dimension of 1sq.ft.each nest.

Construction of cages

Construction of the house and cages follows. The lot was measured to get the exact area in each treatment. Each sidings of the area were concreted to avoid erosion of filled soil on each

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

block. Nest also constructed and it is made up of plywood a 1x2x12 good lumber as a frame and a set of hinges. Sidings are made up of coco lumber as frame with chicken wire as a division of every cage. Cages of every nest has as dimension of 1sq.ft each with 5 nests for every block. For the other housing condition floor will be concreted for easy gathering of data and samples and easy access during feeding and watering and collection of chicken dung.

Stair-step cage housing condition bears a number in each replications and treatments; and used same type of treatment in each layer. Same numbers of heads was being used. The cages were already built, repaired and utilized. Size of each cage is 1x1x1.5ft. Length of this cage is 13.5ft.

Experimental Materials

The experimental materials used in this study were 72 heads of upgraded layer, annatto seeds, commercial laying mash, vernier calliper, yolk color fan, electronic weighing scale with a capacity of 5000gx1g/177ozx0.1oz and record book, ballpen, kitchen utensils

Management of the Experimental Animals

Layer chicken were purchased from nearby municipality which was individually selected to insure that the chicken have high laying performance. Nine birds for every cage were leg banded, replicated with corresponding number and color such as silver, green, and red for conventional cages while the stair-step cages were numbered 1 to 3 in every replication. Commercial laying mash available in the market was purchased and given to layers. Ration for daily feed supply was weighed into polythene bags with 100g, 150g and 200g of annatto as feed supplement, after which the packets of feed were distributed. For every feeding session, 1000g of feeds combined with annatto was given. An average of 100grams of feed ration was given for each layer with a minimum of one inch of drinking space using a through type of waterer in which the top edge have same level with the back part of the birds. Amount of water was always available and kept at a minimum and keep clean throughout the experiment. Both treatment groups were subjected to the natural lighting schedule of 14 hours a day during the entire experimental period. Daily cleaning and application of disinfectant available in the local market was used during the production cycle to lessen the spread out of disease that may hamper on the laying performance. The needed data gathered to determine the daily egg production, egg weight, egg size, shell colour of each egg (1 white, 2 light brown and 3 brown), weight of albumen (each laid), color of yolk (each laid), and yolk weight (each laid) were recorded and measured daily.

The data gathered on the laying performance and quality of eggs such as weight of egg, length of eggs, color of eggshell, weight of albumen, weight of yolk and the color of yolk were analyzed using analysis of variance and comparison of mean using Duncan Multiple Range Test.

3. Results and Discussion

Table 1 shows there were significant differences on the effects of different levels of annatto seeds as feed supplement, not significantly affected by the different housing condition and no interaction effect on the laying performances and egg quality of upgraded layers (see Appendix). According to Hunton (1995) and Kekeocha (1984) there are factors that affect the performance of laying hens. The birds usually start to lay at around five months (20 - 21 weeks) of age and continue to lay at an average of 12 months (52 weeks) as they near the moulting period. Furthermore, they stated that during the egg production cycle the management and feeding practices of the breed, age, body weight, laying house and others must be managed effectively and efficiently to control these factors.

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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Table 2 revealed that the levels of annatto seeds in Treatments 1 and 3 had no significant effect on the laying performance but comparably affected by Treatments 2, 3, 4. However, it was observed that the different housing conditions had no significant effects on the laying performance of upgraded layer. This explains that the different housing conditions are not a potent factor that brings about changes in the laying performances fed with levels of annatto seeds as feed supplement (see Appendix). As discussed by Hunton (1995) and Kekeocha (1984) birds typically begin producing eggs in their twentieth or twenty-first weeks and continue for slightly over a year. This is the best laying period and eggs tend to increase in size until the end of the egg production cycle.

As shown on table 3, the different levels of annatto seeds and the interaction between (A x B) significantly affected the weight of eggs in grams while the housing condition has no significant effect (see Appendix). This tells that the size of an egg is expressed in terms of weight varies with different species of birds which is common in some species and breed. It was shown in Table 4 that the weight of eggs in grams was significantly affected by the different levels of annatto seeds but it was not affected significantly by the different housing conditions. Melendez-Martinez *et al*., (2004) revealed that, the inclusions of optimal level of annatto seeds in animal feeds maintain productivity, improve egg yolk, broiler skin and meat color.

Analysis of variance on Table 5 shows that the different levels of annatto seeds and housing conditions has no significant effects on the length of eggs of updated layers. But the interaction between the levels of annatto seeds and different housing conditions has significant effects hence the null hypothesis is rejected. It only shows that achieving high laying performance depends on many factors and the amount of feed given every feeding. In terms of the length of eggs shown on Table 6, it was not significantly affected by the different levels of annatto seeds and housing condition regardless of treatments.

Table 7 shows that the different levels of annatto seeds (A), different housing conditions (B) and interactions between the two sources of variations significantly affected the width of eggs of upgraded layers. Likewise, the DMRT shown on table 8 indicates that the width of eggs fed with different levels of annatto seeds varies from each other and significantly affected by different housing conditions. This further describes that if the substance given to layers were insufficient in the rations the formation of egg is delayed but if the substance were present, expect good performance from the layer.

It was stated on Table 9 that the different levels of annatto seeds (A), the housing conditions (B) and the interaction (A x B) had no variations on the color of eggs shell of upgraded layer. Table 10 indicates that the color of egg shell of upgraded chicken was light brown and significantly no dissimilarities applying the different levels of annatto seeds raised under different housing condition regardless of treatments. This varies with Butcher and Miles (2003) that during the process of egg shell formation is in brown egg layers which accumulate pigments, such as biliverdin-IX these pigments are transferred to the viscous protein rich cuticle that determines the colour of the egg.

It can be gleaned on Table 11 that the different levels of annatto seeds and its interaction effects significantly affected the weight of albumen but not the housing conditions. The result of DMRT on Table 12 states that albumen weight in grams of upgraded layer with 20% of annatto seeds and 80% commercial laying mash was significantly heavier than other treatments while Treatments 1, 2, and 4 were comparable from each other and the different housing conditions do not significantly affected the albumen weight of upgraded layer. This further describes that normal albumin is transparent, with a slightly yellow green colour. The discolouration of the albumin like becoming much yellower may occur if the eggs are stored for an extended time period in poor conditions.

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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Table 13 indicates that the different levels of annatto seeds and the different housing conditions significantly shows no variations on the weight of yolk of upgraded layers but the interaction effect differs. Likewise, the result of DMRT analysis on Table 14 shows that the different levels of annatto seeds and housing conditions were not significantly affected the weight of egg yolk regardless of treatments. This clarifies that cages promotes hygiene in egg production (Awoniyi, 2003). Al-Rawi and Abu-Ashour, et al (1983) and Abrahmansson et. Al, (1996) found out that stair-step cages had significantly higher production and shell thicknesses of the eggs were significantly greater than those from hens in floor plans. The result was also influenced by Constant et. al (2002) that pigments are extremely important to egg yolk color derived from the deposition of xanthropylls which are not synthesized by the birds and therefore must be obtained from the diet derived from natural resources. On the other hand, annatto which is high in carotenoid content provides beneficial antioxidant properties on hens.

As shown on Table 15, the different levels of annatto seeds varies significantly on the egg yolk of upgraded chicken while it do not differs significantly on the different housing conditions and there was no interaction effect. On the other hand, the different levels of annatto seeds implies on Table 16 shows significant variations in every treatment on the color of the egg yolk but it was not affected significantly by the different housing conditions. This justifies that the color of egg yolk is one of the important factor for egg consumption. Hence, Fletcher (1999) described that the egg yolk color is produced by caroteneoids such as carotenes and xanthophylls in which pigmentation has two important factors such as the storage ability of the pigment in the egg yolk and the wave length of the pigment. Smith (1996), and Taplin, *et al.* (1983) determined that the presence and absence of some xanthophylls are precursor of vitamin A in which the colour of the yolk is influenced by a large degree of nutrition and dark yellow yolks can be produced by feeding laying birds on grass meal.

4. Conclusion

Based on the findings, it was concluded that variations were observed on the different levels of annatto seeds and housing conditions. Hence, the poultry raisers may use annatto seeds as feed supplement to enhance the quality of eggs and as therapeutic agent to treat diseases that reduce the production of eggs, should use both the conventional and stair-step housing to improve the laying performance of upgraded chicken, and the poultry raisers should engage in annatto shrub plantation to support the needs of the consumers.

5. Acknowledgement

This humble piece of work is dedicated to the **GOD ALMIGHTY**, for His unbounded love, protection and guidance and to our family, friends, co-teachers, professors, administration of the university and to all persons who were mentioned who inspired us to pursue this undertaking.

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BioChemMed

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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7. Appendices

Table 1. Analysis of variance on the laying performance of the upgraded layers as affected by different levels of annatto seeds raised under different housing conditions

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F- Critical	
					5%	1%
Annatto Seeds(A)	3	3,194.830	1.064.930	14.40**	3.24	5.29
Housing (B)	1	4.163	4.163	0.06^{ns}	4.49	8.53
Interaction (A x B)	3	263.504	87.835	1.19^{ns}	3.24	5.29
Error	16	1,183.333	73.958			
Total	**23**	**4,645.830**				

CV-21.93% ns – Not Significant **Significant at 1% level

Table 2. Laying performance of upgraded layers as affected by different levels of annatto seeds raised under different housing conditions.

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I - 10% Annatto and 90% Laying mash	45	47	46 a
T_{II} -15% Annatto and 85% Laying mash	25	22	24 b
T_{III} - 20% Annatto and 80% Laying mash	37	30	34 ab
T_{IV} - 100% Laying mash	10	21	16 b
MEAN	**29 a**	**30 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Table 3. Analysis of variance on the weight of egg in grams of the upgraded layers as affected by different levels of annatto seeds raised under different housing conditions.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F-Critical	
					5%	1%
Annatto Seeds(A)	3	32.960	10.990	3.402*	3.24	5.29
Housing (B)	1	.045	.045	0.014^{ns}	4.49	8.53
Interaction (A x B)	3	46.380	15.460	4.786*	3.24	5.29
Error	16	51.673	3.230			
Total	**23**	**131.058**				

CV-4.79% ns - Not Significant *Significant at 5% level

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

Table 4. Weight of eggs in grams of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I- 10% Annatto and 90% Laying mash	34.59	39.19	36.89 b
T_{II} -15% Annatto and 85% Laying mash	38.32	36.31	37.32 ab
T_{III} - 20% Annatto and 80% Laying mash	39.71	39.06	39.39 a
T_{IV}- 100% Laying mash	37.41	35.5	36.46 b
MEAN	**37.51 a**	**37.52 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Table 5. Analysis of variance on the length of eggs of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Source of Variation	**Degree of Freedom**	**Sum of Squares**	**Mean Square**	**F-Value**	**F-Critical**	
					5%	**1%**
Annatto Seeds(A)	3	2.3600	0.7870	1.88^{ns}	3.24	5.29
Housing (B)	1	0.3568	0.3586	0.85^{ns}	4.49	8.53
Interaction (A x B)	3	16.6210	5.5400	13.22**	3.24	5.29
Error	16	6.7150	0.4190			
Total	**23**	**26.0530**				

CV-1.30% ns - Not Significant **Significant at 1% level

Table 6. Length of eggs of upgraded layer as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I - 10% Annatto and 90% Laying mash	48.14	50.67	49.41 a
T_{II} -15% Annatto and 85% Laying mash	50.75	48.87	49.81 a
T_{III} - 20% Annatto and 80% Laying mash	50.72	49.88	50.30 a
T_{IV} - 100% Laying mash	50.16	49.37	49.77 a
MEAN	**49.94 a**	**49.70 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

Table 7. Analysis of variance on the width of eggs of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F-Critical	
					5%	1 %
Annatto Seeds(A)	3	10.59	3.53	5.60**	3.24	5.29
Housing (B)	1	4.77	4.77	7.57*	4.49	8.53
Interaction (A x B)	3	17.84	5.95	9.44**	3.24	5.29
Error	16	10.06	0.63			
Total	**23**	**43.26**				

CV-2.14% ns - Not Significant **Significant at 1% level

Table 8. Width of eggs of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I - 10% Annatto and 90% Laying mash	34.30	37.99	36.15 c
T_{II} -15% Annatto and 85% Laying mash	37.10	37.34	37.22 b
T_{III} - 20% Annatto and 80% Laying mash	37.70	38.33	38.02 a
T_{IV}- 100% Laying mash	37.65	36.66	37.16 b
MEAN	**36.68 b**	**37.58 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

Table 9. Analysis of variance on the color of the egg shell of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F-Critical	
					5%	1%
Annatto Seeds(A)	3	0.126	0.042	0.592^{ns}	3.24	5.29
Housing (B)	1	0.021	0.021	0.296^{ns}	4.49	8.53
Interaction (A x B)	3	0.396	132	1.859^{ns}	3.24	5.29
Error	16	1.130	0.071			
Total	**23**	**1.673**				

CV-14.89% ns - Not Significant

Table 10. Color of eggs shell of upgraded layers as affected by levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN	DI
	Conventional Litter Floor	Stair Step		
T_I - 10% Annatto and 90% Laying mash	1.61	2.03	1.82 a	LB
T_{II} -15% Annatto and 85% Laying mash	1.74	1.60	1.67 a	LB
T_{III} - 20% Annatto and 80% Laying mash	1.83	1.75	1.79 a	LB
T_{IV} -100% Laying mash	1.85	1.88	1.87 a	LB
MEAN	**1.76 a**	**1.82 a**		
DI	**LB**	**LB**		

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT (Rating Scale: 2.51- 3.0 Brown (B), 1.51- 2.50 Light Brown (LB), 1.0 - 1.50 White (W)

Table 11. Analysis of variance on the weight of egg albumen in grams of upgraded layers as affected by different levels of annatto seeds different housing conditions

Source of Variation	**Degree of Freedom**	**Sum of Squares**	**Mean Square**	**F-Value**	**F-Critical**	
					5%	**1%**
Annatto Seeds (A)	3	9.343	3.1140	5.48**	3.24	5.29
Housing (B)	1	0.823	.0823	0.14^{ns}	4.49	8.53
Interaction (A x B)	3	18.598	6.1990	10.91**	3.24	5.29
Error	16	9.086	0.5680			
Total	**23**	**37.85**				

CV-4.25% ns - Not Significant **Significant at 1% level

Table 12. Weight of egg albumen in grams of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I - 10% Annatto and 90% Laying mash	15.96	18.33	17.15 b
T_{II} -15% Annatto and 85% Laying mash	18.58	17.00	17.79 b
T_{III} - 20% Annatto and 80% Laying mash	18.78	18.71	18.75 a
T_{IV}-100% Laying mash	18.42	16.12	17.32 b
MEAN	**17.94 a**	**17.56 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Technium BioChemMed Vol. 2, Issue 2 pp.125-138 (2021)
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www.techniumscience.com

Table 13. Analysis of variance on the weight of yolk in grams of upgraded layers as affected by different levels of annatto seeds and different housing conditions.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F-Critical	
					5%	1%
Annatto Seeds(A)	3	3.79	1.26	1.68^{ns}	3.24	5.29
Housing (B)	1	0.68	0.68	0.19^{ns}	4.49	8.53
Interaction (A x B)	3	14.06	4.69	6.25**	3.24	5.29
Error	16	11.94	0.75			
Total	**23**	**30.471**				

CV-5.44% ns - Not Significant **Significant at 1% level

Table 14. Weight of the yolk in grams of upgraded layers as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN
	Conventional Litter Floor	Stair Step	
T_I - 10% Annatto and 90% Laying mash	14.13	16.90	15.52 a
T_{II} -15% Annatto and 85% Laying mash	15.84	15.32	15.58 a
T_{III} - 20% Annatto and 80% Laying mash	16.29	16.68	16.49 a
T_{IV} - 100% Laying mash	16.77	15.48	16.13 a
MEAN	**15.76 a**	**16.095 a**	

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Table 15. Analysis of variance on the egg yolk color of up-graded layers as affected by different levels of annatto seeds and different housing conditions

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Value	F-Critical	
					5%	1%
Annatto Seeds (A)	3	27.744	9.248	8.4969**	3.24	5.29
Housing (B)	1	0.125	0.125	0.115^{ns}	4.49	8.53
Interaction (A x B)	3	1.6195	0.5398	0.4959^{ns}	3.24	5.29
Error	16	17.4144	1.0884			
Total	**23**	**46.9029**				

CV-12.85% ns - Not Significant **Significant at 1% level

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Table 16. Egg yolk color of upgraded layer as affected by different levels of annatto seeds and different housing conditions

Levels of Annatto Seeds	Housing		MEAN	DI
	Conventional Litter Floor	Stair Step		
T_I - 10% Annatto and 90% Laying mash	7.65	8.38	8.02 b	O
T_{II} -15% Annatto and 85% Laying mash	8.46	8.21	8.34 ab	O
T_{III} - 20% Annatto and 80% Laying mash	9.84	9.29	9.57 a	OR
T_{IV} -100% Laying mash	6.8	6.29	6.55 a	YO
MEAN	**8.19 a**	**8.04 a**		
DI	**O**	**O**		

Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Mean	**Descriptive Interpretation (DI)**	**Mean**	**Descriptive Interpretation (DI)**
13.51-14	Red (R)	5.51-7.50	Yellow Orange (YO)
11.51-13.50	Red Yellow (RY)	3.51-5.50	Yellow (Y)
9.51-11.50	Orange Red (OR)	1.0 - 3.50	Pale Yellow (PY)
7.51-9.50	Orange (O)		