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Factorial Analysis to Investigate the Effect of different Housing System, Incubators type and Bird Species on the Size of Egg

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Abstract

This research work investigates the effect of different housing system, incubator types and bird species on the size of an egg; it examines which of the incubators, housing system and species of birds contribute most to the size of an egg; and derives model for obtaining the possible optimal size of egg for the best bird species. A 3X3 factorial design was used in the data analysis to establish if different Housing system, incubators type and, Bird species contribute to the size of an egg; LSD, scheffer, Bonferroni and Response Surface methodology were employed to determine which of the housing system, incubators and bird species contribute most to the size of egg and a derived multiple regression model were obtained to know the optimal size of an egg for the best bird species. Data analyses were carried out, and the results showed that Housing system, Incubator types, and bird species have effect on the size of an egg. However, Hovabator, Cage System, and Broiler Breeder are the best Incubators, Housing system, and the best Bird species respectively are recommended. The derived model for egg size was obtained as: $Y_{opt} = 99.55806 + 0.534507I + 0.499052H + 3.248082S - 0.167206IH - 0.965228IS - 0.578039HS + 0.247904IHS$. Hence, to get an optimal egg size of 106.28 grams, Hovabator, Cage System, and Broiler Breeder are to be used.

Keywords: ***Housing System, Incubators, Bird Species, Egg size, factorial Analysis and Response surface methodology***

1.0. Introduction

Poultry meat and egg are the most common animal source food consumed at the global level through the wide diversity of culture, tradition, and religion and making them the key to food security and nutrition. Presently the world has over 23 billion poultry birds about three per person on the planet (FAOSTAT, 2016). Poultry products are among the most abundant sources of animal protein for all classes of people in Africa. In terms of food conversion, poultry eggs rank with cow's milk being the most economically produced animal protein and in terms of biological value, poultry products rank highest (Leitch and Godden, 1941). In the tropics, poultry are kept either for the supply of animal protein to the family in rural areas or for the supply of protein to the urban workers and other concentra-tions of money-earning communities. Thus the need to increase the supply of poultry products to cater for the ever expanding populations is much more felt now than ever before. To increase the production of poultry and their products, especially eggs, elaborate methods of management must be undertaken including the provision of well ventilated clean housing and the incubators type and the type of birds. The birds should be provided with a comfortable environment so that they achieve their maximum genetic potential for production because, with the right kind of stock and suitable housing and food supply, the production of eggs is likely to be in direct proportion to the comfort of the birds. Currently, commercial poultry producers retain a preference for one housing system or the other without sufficient experimental support. Reports on the effect of housing systems on poultry production have been contra-dictory. Ensminger (1971) reported that birds on deep litter feel comfortable but there is usually a high incidence of bacterial diseases.

1.1. Egg Size

All over the world, eggs are marketed based on consumers' weight class. The use of consumer weight classes ensures continuity of egg within an egg carton, and guarantees that consumers are receiving a homogeneous size distribution. Those market for shell egg consist of three primary weight class (weight/ dozen); medium size (59g), Large size (68g) and extra-large size (76g). It is general knowledge that genetic selection is practiced in anticipation of consumer purchasing preferences, including egg size. Furthermore, it is generally known that production practices and physiological stress can directly impact egg size (Cunninghan et al., 1996); Gardner and Young, 1972, Summers and Leeson 1983; Morris, 1985; Kehavarz and Nakajima, 1995) therefore it is often difficult to determine if housing changes or other factors like incubators type and the species of bird are affecting egg size and quality. There is a large degree of variability in the research finding of the effect of various housing systems on the size of an egg.

1.2 Materials and methods

In statistics, a full factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factors(). A full factorial design may also be called a fully crossed design. Such an experiment allows the investigator to study the effect of each factor on the response variable, as well as the effects of interactions between factors on the response variable () . The model for factorial experiment depends on the numbers of factors to be investigated in the experiment since the general factorial design does not have a unique Potassium respectively) are to be investigated on Cassava, then the model for the design adopted is stated below.

$Y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + Ɣ_k + (\tauƔ)_{ik} + (\betaƔ)_{jk} + (\tau\betaƔ)_{ijk} + e_{ijk}$

Where:

Y_{ijk} observation recorded for i^{th}, j^{th},k^{th} at the level of factors respectively

μ is the overall mean, τ_i is the i^{th} effect of factor incubators, β_k is the j^{th} effect of thefactor housing system, $Ɣ_k$ is the k^{th} effect of the factor bird species, $(\tau\beta)_{ij}$ is the interaction effect of the incubators and housing systems, $(\tauƔ)_{ik}$ is the interaction effect incubators and bird species, $(\betaƔ)_{jk}$ is the interaction effect of housing system and bird species, $(\tau\betaƔ)_{ijk}$ is the interaction effect of housing systems, incubators and bird species; and ε_{ijk} is the random error.

In this research work, three different types of incubators were examined which are: Hovabator, GQF1588 Genesis incubator, and Brinsea Mini II Advance; Three different housing systems: Cage System, Deep Litter System, and free-range; and Three different birds species: Isa brown, Bovas Nera and Broiler Breeder. Hence, I – Incubator, H – Housing System, S – Bird Species.

Table 2.1: ANOVA Results of the Egg Size

Source of Variation	Sum of Squares	df	Mean Squares	F_{cal}	Sig.	Remark
Corrected Model	210.002[a]	26	8.077	.096	.000	Sig.
Intercept	307058.008	1	307058.008	3652.180	.000	Sig.
I	15.318	2	7.659	.091	.915	Not Sig.
H	5.513	2	2.757	.033	.968	Not Sig.
S	55.361	2	27.681	.329	.743	Not Sig.
I * H	42.036	4	10.509	.125	.964	Not Sig.
I * S	12.230	4	3.058	.036	.996	Not Sig.
H * S	2.500	4	.625	.007	1.000	Not Sig.
I * H * S	40.141	8	5.018	.060	.009	Sig.
Error	252.226	3	84.075			
Total	321260.730	30				
Corrected Total	462.228	29				

R Squared = .454 (Adjusted R Squared = -4.275)

The result indicated that the fittest model is the factorial design since the corrected model is significant with the value of 0.000, which lesser than the level of significance 0.05. It can be affirmed that only the combination of the three variables, Incubator*Housing System*Bird Species (IHS), has a significant effect on egg size of the farm at a 5% level of significance, while others are insignificant at 5% level when applied together.

The post Hoc Analysis

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Since the combination of Incubator, Housing System, and Bird Species were significant at 5%, we, therefore, carry out a Post Hoc Analysis; the LSD, Tukey, Scheffer, and Bonferroni. The test was carried out to know which level of the factors differ from the rest; let I_1, I_2, and I_3 be the levels of Incubator; H_1, H_2, and H_3 be the levels of Housing System and S_1, S_2 and S_3 be the levels of Bird Species.

Table 2.2: Post-Hoc Analysis of Incubator on the Egg Size

	(I) I	(J) I	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	1	2	-1.3489	4.32243	.953	-20.2415	17.5437
		3	.7547	4.04326	.983	-16.9177	18.4271
	2	1	1.3489	4.32243	.953	-17.5437	20.2415
		3	2.1036	4.04326	.878	-15.5688	19.7760
	3	1	-.7547	4.04326	.983	-18.4271	16.9177
		2	-2.1036	4.04326	.878	-19.7760	15.5688
LSD	1	2	-1.3489	4.32243	.775	-15.1048	12.4070
		3	.7547	4.04326	.864	-12.1127	13.6222
	2	1	1.3489	4.32243	.775	-12.4070	15.1048
		3	2.1036	4.04326	.639	-10.7639	14.9711
	3	1	-.7547	4.04326	.864	-13.6222	12.1127
		2	-2.1036	4.04326	.639	-14.9711	10.7639
Bonferroni	1	2	-1.3489	4.32243	1.000	-22.3414	19.6437
		3	.7547	4.04326	1.000	-18.8820	20.3915

	2	1	1.3489	4.32243	1.000	-19.6437	22.3414
		3	2.1036	4.04326	1.000	-17.5331	21.7403
	3	1	-.7547	4.04326	1.000	-20.3915	18.8820
		2	-2.1036	4.04326	1.000	-21.7403	17.5331

Table 2.3: Post-Hoc Analysis of House System on Egg Size

	(I) H	(J) H	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	1	2	1.7935	4.00634	.908	-15.7176	19.3045
		3	.4402	4.21298	.995	-17.9740	18.8545
	2	1	-1.7935	4.00634	.908	-19.3045	15.7176
		3	-1.3532	4.12127	.948	-19.3666	16.6602
	3	1	-.4402	4.21298	.995	-18.8545	17.9740
		2	1.3532	4.12127	.948	-16.6602	19.3666
LSD	1	2	1.7935	4.00634	.685	-10.9565	14.5434
		3	.4402	4.21298	.923	-12.9674	13.8478
	2	1	-1.7935	4.00634	.685	-14.5434	10.9565
		3	-1.3532	4.12127	.764	-14.4690	11.7625
	3	1	-.4402	4.21298	.923	-13.8478	12.9674
		2	1.3532	4.12127	.764	-11.7625	14.4690
Bonferroni	1	2	1.7935	4.00634	1.000	-17.6639	21.2509

		3	.4402	4.21298	1.000	-20.0208	20.9012
	2	1	-1.7935	4.00634	1.000	-21.2509	17.6639
		3	-1.3532	4.12127	1.000	-21.3688	18.6624
	3	1	-.4402	4.21298	1.000	-20.9012	20.0208
		2	1.3532	4.12127	1.000	-18.6624	21.3688

Table 2.4: Post-Hoc Analysis of Bird Species on the Egg Size

	(I) S	(J) S	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	1	2	1.2150	4.10062	.958	-16.7081	19.1381
		3	-2.5450	4.10062	.834	-20.4681	15.3781
	2	1	-1.2150	4.10062	.958	-19.1381	16.7081
		3	-3.7600	4.10062	.690	-21.6831	14.1631
	3	1	2.5450	4.10062	.834	-15.3781	20.4681
		2	3.7600	4.10062	.690	-14.1631	21.6831
LSD	1	2	1.2150	4.10062	.786	-11.8350	14.2650
		3	-2.5450	4.10062	.579	-15.5950	10.5050
	2	1	-1.2150	4.10062	.786	-14.2650	11.8350
		3	-3.7600	4.10062	.427	-16.8100	9.2900
	3	1	2.5450	4.10062	.579	-10.5050	15.5950
		2	3.7600	4.10062	.427	-9.2900	16.8100

Bonferroni	1	2	1.2150	4.10062	1.000	-18.7003	21.1303
		3	-2.5450	4.10062	1.000	-22.4603	17.3703
	2	1	-1.2150	4.10062	1.000	-21.1303	18.7003
		3	-3.7600	4.10062	1.000	-23.6753	16.1553
	3	1	2.5450	4.10062	1.000	-17.3703	22.4603
		2	3.7600	4.10062	1.000	-16.1553	23.6753

The results showed that none of the three factors is significant since they were not significant in the general model.

1.2. Response Surface Method

The analysis below was done using coded units through Estimated Regression Coefficients for yield.

Table 2.5: Response Surface Regression: Egg Size versus I, H, S

Egg Size =C(1)+C(2)*I+C(3)*H+C(4)*S+C(5)*I*H+C(6)*I*S+C(7)*H*S+C(8)*I*H*S

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	99.55806	15.71652	6.334614	0.0000
C(2)	0.534507	7.134549	0.074918	0.9410
C(3)	0.499052	7.317942	0.068196	0.9462
C(4)	3.248082	7.178213	0.452492	0.6553
C(5)	-0.167206	3.355188	-0.049835	0.9607

C(6)	-0.965228	3.180869	-0.303448	0.7644
C(7)	-0.578039	3.355188	-0.172282	0.8648
C(8)	0.247904	1.513122	0.163836	0.8714
R-squared	0.085427	Mean dependent var		103.1723
Adjusted R-squared	-0.205573	S.D. dependent var		4.063091
S.E. of regression	4.461217	Akaike info criterion		6.051898
Sum squared resid	437.8540	Schwarz criterion		6.425551
Log likelihood	-82.77848	Hannan-Quinn criter.		6.171433
F-statistic	0.293564	Durbin-Watson stat		1.030427
Prob(F-statistic)	0.949254			

The regression equation for the linear and interaction between the factors using the coded unit from the above table is given thus; $Y_{egg\ size} = 99.55806 + 0.534507I + 0.499052H + 3.248082S - 0.167206IH - 0.965228IS - 0.578039HS + 0.247904IHS$. The goodness of fit was determined by the R-squared value of 8.5% with the overall significant test value of Prob(F-statistic) = 0.949 which indicates that different levels of Egg Size showed kind of insignificant difference at 5% level of significance using the variables (Incubator, Housing System and Bird Species).

2.3. Estimation of Egg Size Maximum Levels

Overall Model: Egg Size $Y_{opt} = 99.55806 + 0.534507I + 0.499052H + 3.248082S - 0.167206IH - 0.965228IS - 0.578039HS + 0.247904IHS$, this model will be the appropriate method to know the maximum yield in order to confirm the real levels of the used three variables (I, H and S) to give the significant maximum Egg Size.

Table 4.6: Estimation of Maximum Egg Size using Significant and Overall Model

I	H	S	Rep1	Rep2	Yield	Max Yield
1	1	1	50.52	51.53	102.05	102.3771
1	1	2	51.53	51.55	103.08	104.3299
1	**1**	**3**	52.55	52.55	105.1	**106.2826**
1	2	1	50.53	52.54	103.07	102.3788
1	2	2	52.55	53.55	106.1	104.0014
1	2	3	51.54	53.55	105.09	105.624
1	3	1	49.51	50.54	100.05	102.3806
1	3	2	50.55	49.53	100.08	103.673
1	3	3	52.56	52.57	105.13	104.9655
2	1	1	51.55	51.55	103.1	102.0271
2	1	2	51.54	50.54	102.08	103.2625
2	1	3	53.57	54.56	108.13	104.4979
2	2	1	49.53	52.54	102.07	102.1095
2	2	2	50.54	51.53	102.07	103.2627
2	2	3	51.56	53.57	105.13	104.4158
2	3	1	54.56	53.54	108.1	102.1919
2	3	2	52.56	52.55	105.11	103.2629
2	3	3	52.55	53.55	106.1	104.3338
3	1	1	48.5	55.57	104.07	101.6771
3	1	2	51.55	52.58	104.13	102.1952

3	1	3	54.56	50.56	105.12	102.7132
3	2	1	49.5	52.53	102.03	101.8402
3	2	2	52.56	55.56	108.12	102.5239
3	2	3	51.53	53.55	105.08	103.2077
3	3	1	49.52	53.56	103.08	102.0033
3	3	2	51.53	49.54	101.07	102.8527
3	3	3	54.58	50.52	105.1	103.7021
3	1	3	44.6	55.07	99.67	102.7132
3	2	1	52.6	47.8	100.4	101.8402
3	2	2	50.06	35.6	85.66	102.5239

2.0. Conclusion

From the above tables 2.5 and 2.6, it is observed that the maximum egg size is 106.2826 for the overall model, which is the variable combination of the first Incubator, first Housing system, and third Bird species, i.e. I_1, H_1 and S_3 for the egg size. Hence, the type of Housing system used, Incubator types, and bird species determine the size of the egg. However, Hovabator, Cage System, and Broiler Breeder are the best Incubators, Housing system, and the best Bird species respectively are recommended. The derived model for egg size was obtained as: $Y_{opt} = 99.55806 + 0.534507I + 0.499052H + 3.248082S - 0.167206IH - 0.965228IS - 0.578039HS + 0.247904IHS$. Hence, to get an optimal egg size of 106.2826 grams, Hovabator, Cage System, and Broiler Breeder are recommended.

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