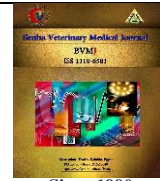




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Effect of layer breeds on the productivity and profitability of layer farms under Egyptian condition

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ABSTRACT

This study was carried out during the period extended from the year 2019 to the year 2021 on four-layer breeds (Lohmann (LB), ISA Brown, Hy-Line W-36, and Hy-Line Brown) of the layer farms in EL-Menofia governorate, the data were collected from the accurate health and production records and, by using the structured questionnaires methods. This study aims to determine and highlight the effect of different layer breeds on the productivity and profitability of layer farms under Egyptian condition, also it indicated that the layer breed is the major factor that can affect the egg production and net profit of layer farms, This study concluded that the egg production significantly differed among the layer breeds it was the highest for ISA Brown breed (35603.97 eggs/100 hens/cycle), while it was the lowest for Hy-Line Brown breed (25368.37 eggs/100 hens /cycle), also the total return and net profit differed significantly among the layer breeds and they were the highest for ISA brown breed (49604.26 and 6426.18 EGP/100 hens, respectively), while they were the lowest for Hy-Line Brown breed (35859.55 and 497.79 EGP/100 hens, respectively). Finally, we concluded that the ISA Brown breed is the most profitable breed to be reared in the layer farms.

1. INTRODUCTION

Poultry production plays a major role in providing a large and cheap source of animal protein in Egypt. The layers usually start laying at about 20 weeks of age and the peak of egg production is attained during the first production cycle (at about 32 weeks) (Singh and Groves, 2020). Eggs are the major business outputs in a commercial table egg production and the higher egg production the better will be the profit (Rayan et al., 2013). Egg production is a dependent variable and is influenced by several factors like breed, hen age, feeding, mortality rate, and health and management practices (Tolimir and Mašić, 2000). Eggs represent a “complete food” required for human with a balance of essential nutrients to sustain both life and growth (Iannotti et al., 2014 & Singh et al., 2012). In both developed and developing countries, increased egg production and consumption could significantly improve the nutritional needs of children and adults (Miranda et al., 2015). In a commercial poultry production system, profit can be attained by minimizing feed cost which accounts for about 60 - 70% of the total cost of production (Adegbenro et al., 2012). The recent increase in the price of inputs (feed and chicks) adversely affected layer farming at a local level (Rafeeq et al., 2013). Al-Khalifa and Ragheb (2013) demonstrated that utilizing strains that produce brown eggs with high quality is essential for producers to improve their production efficiency, reduce their costs and be able to improve profitability and compete with the imported products in terms of price and quality. The

breeds are regarded as efficient by producing a Kg of egg with a feed of not more than 2.5 kg. There are two types of egg layers, the white and the brown egg-laying hens. The white egg-laying hens are comparatively smaller in size, relatively eat less food, with white shell-colored eggs compared with the brown egg-laying hens that are relatively larger in size, eat more foods, lay bigger eggs with brown shell than other laying breeds (Bogale and Edae, 2020). Hy-Line brown and Hy-Line W-36 are commercial hybrid strains, Rayan et al. (2013) demonstrated that Hy-Line brown strain had significantly heavier body weight, egg weight and consumed more feed compared to the Hy-Line W-36 ones, but the W-36 layers strain had a better feed conversion ratio compared to the brown strain. Lohmann Brown is a crossbreed, brown-egg laying chicken (*Gallus gallus domesticus*) which was selectively bred in Germany, from New Hampshire and other brown-egg-laying breeds (Hinsemu et al., 2018). These birds lay an average of 312-320 eggs per year (Feltwell, 2011). Rate of mortality in Lohman Brown was 1.67 (Singh et al., 2009). ISA Brown is a hybrid of Rhode Island Red (a hen) and Rhode Island White (cock). It is characterized by its high egg production of approximately 300 eggs/hen in the first year of lying. They give colored brown eggs with excellent shell quality (Hinsemu et al., 2018). Islam and Kabir (2021) found that eggs of ISA brown were common in the market because their size was bigger than the others and the color was preferred by most customers. Eggs are a nutritious food, offering a balanced source of essential fatty and amino acids, minerals, and vitamins. The average daily feed intake, body weight,

egg weight, and egg production of the hen are important measures of productivity in the layer industry (Anene et al., 2020). So, this study aims to determine the effect of layer breeds on the productivity and profitability of layer farms.

2. MATERIAL AND METHODS

The current work was approved by the Committee of Animal Care and Welfare, Benha University, Faculty of Veterinary Medicine, Egypt (BUFVTM: 07-12-20).

This study was carried out during the period extended from the year 2019 to the year 2021 on different layer breeds of the layer farms in EL-Menofia, governorate. The data were collected from accurate health and production records and, by using the structured questionnaires, the data were collected for four different Layer breeds (Lohmann (LB), ISA Brown, Hy-Line W-36, and Hy-Line Brown) that were reared in the caging system.

2.1. These data were categorized into:

2.1.1. Production traits and resources: That included, breed type, number of day-old chicks, amount of rearing and production rations consumed (Kg), age at the beginning of laying, total egg production/cycle/100hens and mortality percentage.

2.1.2. Production costs: That included the fixed costs (building and equipment depreciation). And the variable costs (the prices of drugs, vaccines, disinfectants, veterinary supervision, feed cost, hen cost, labor cost, and electricity during the whole production cycle /100 hens) according to (Atallah, 2000)

2.1.3. Production returns: That included the returns from the total egg sales, hen sales and litter sale at end of the production cycle /100 hens.

2.2. Productive and economic data calculation

1. The Egg Production/Housed Hens (North, 1984) = total number of eggs produced by the flock / total number of the housed hens
2. Feed conversion rate = Egg mass (Kg)/feed intake (kg)
3. Feed conversion per dozen eggs (Abdel-Wahed, 1998) = Feed consumed (Kg) ×12 / total egg produced
4. Total costs per Egyptian pound = total fixed costs + total variable costs (Abd-El Hamed and Kamel, 2021).
5. Total variable costs per Egyptian pound = feed + hen value + labor + water and electricity + total veterinary management (Kamel, 2016).
6. Fixed costs = building and equipment depreciation (Abd-El Hamed et al., 2017).
7. Total return = egg sales + hen + litter sale (Sallam et al., 2019).
8. Net profit = total return –total cost (Atallah, 1994).

2.3. Statistical analysis

All statistical procedures were performed using the computer programs SPSS/PC+ "version 23"(SPSS, 2015). Preliminary Levene's test was performed to ensure the homogeneity of variances among groups. One Way ANOVA was used to analyze the production, and economic measures on one hundred hens to determine means of variables among different breeds. Duncan's Multiple Range-Test was used to test the differences among means. Statistical significance between mean values was set at ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

The local poultry industry is one of the most important animal industries in the country, so improving their production efficiency is essential for producers to reduce their costs and be able to improve profitability and compete with the imported products in terms of price and quality, so our study was carried out to study the effect of layer breeds on the egg number, egg mass, FCR, and profitability of layer farms. Effect of layer breeds on some productive traits of layer farms are presented in Table (1).

Regarding the feed intake during the rearing stage, it differed significantly among different breeds, it was the highest for Hy-line Brown (735.21kg), while it was the lowest for Lohmann (LB) (662.27 kg), this result disagreed with Dutta et al. (2012) who reported that the feed intake was the lowest for ISA Brown breed. Concerning the feed intake, egg number, egg mass, FCR, FCR (dozen egg), and final hen weight during the production stage, they differed significantly among different breeds, the highest feed intake and final hen weight were for Lohmann (LB) (5125.07 & 207 Kg, respectively) and they were the lowest for Hy-Line W-36 (3826.34 & 152 kg, respectively), these results in accordance with Xin et al. (2006) who concluded that the feed intake and final hen weight differed significantly among different breeds, and the Lohmann (LB) breed showed the highest feed intake (47.04 Kg/hen) and final hen weight (1.91kg/hen), while they were the lowest (39.9 & 1.50 kg/hen, respectively) for the Hy-Line W-36, also Yigzaw et al. (2021) noted that body weight was the highest for the Lohmann (LB) breed. In contrast, Sosnówka-Czajka et al. (2011) reported that feed consumption was the highest for Hy-Line W-36 while it was the lowest for Lohmann (LB). The highest egg number (35602.97 eggs/100 hens) was noted for ISA Brown, and it was the lowest (25368.37eggs/100 hens) for Hy-line Brown. While the highest egg mass (2278.59 Kg) was found for ISA Brown, and it was the lowest (1607.60 Kg) for Hy-Line W-36. Regarding the FCR, it was the best for ISA Brown (2.22), followed by Lohmann (LB), Hy-Line W-36, and Hy-line Brown (2.26, 2.38 & 2.38, respectively), these results agreed with those of Estrada Pareja and Restrepo Betancur (2015) who concluded that the ISA Brown achieved better results for the main performance parameters, also these results in the same line with Rayan et al. (2013) who concluded that the W-36 layers strain had a better feed conversion ratio compared to the Hy- Line brown strain. While these results disagreed with Xin et al. (2006) who showed that the FCR was the best for Hy-Line W-36 and Hy-line Brown (1.77 & 1.99, respectively), while it was higher for ISA Brown (2). The results concerning the egg mass agreed with Al-Khalifa and Ragheb (2013) who stated that brown hens would produce more egg mass than white hens. Mortality percentage among the different layer breeds is presented in Table (5) & Chart (2); concerning the mortality percentage during the rearing stage, it had a non-significant effect among the different layer breeds, while it had a significant effect among different breeds during the production stage, the lowest mortality % (7.4) was noted for ISA Brown and the highest one (12.69) was for Hy-Line W-36. A significant effect of breed on the mortality of laying hens was also found by Sørensen (2001) who determined the mortality rate for Isa Brown hens was 19.9 %. Other studies showed that mortality % for ISA Brown was 6% Rakonjac et al. (2021) and for Lohmann (LB) was 2.83% (Yigzaw et al., 2021). Economic indices are presented in tables (2&3) and Chart (1); The costs of layer farms during the rearing and production stages differed significantly among the four breeds, concerning the rearing stage the feed cost and total cost were the highest for the Hy-Line Brown breed (5881.71

&7631 EGP, respectively), while they were the lowest for the Lohmann breed (5298.14 & 7048.14EGP, respectively), but for the production stage the feed cost and total cost were the highest for the Lohmann breed (35875.52 &36525.52 EGP, respectively), while they were the lowest for Hy-Line W-36 (26784.36 & 27434.36 EGP, respectively), finally, the

feed cost and TC during the whole cycle differed significantly among the four-layer breeds, they were the highest for Lohmann breed (41173.66 &43573.66 EGP, respectively), while they were the lowest for Hy-Line W-36 (32125.72 & 34525.72 EGP, respectively), this variation is due to different feed consumption among breeds.

Table 1 Effect of layer breeds on some productive traits of layer farms.

Items	Lohmann (LB)	ISA Brown	Hy-Line W-36	Hy-Line Brown
	----- Rearing Stage -----			
Feed Intake (Kg)	662.27 ^b ± 27.69	664.55 ^b ± 3.15	667.67 ^b ± 9.07	735.21 ^a ± 3.95
	----- Production Stage -----			
Feed Intake (Kg)	5125.07 ^a ± 77.77	5065.95 ^a ± 20.88	3826.34 ^b ± 12.02	3868.58 ^b ± 18.63
Egg Number	35372.53 ^b ± 412.28	35602.97 ^b ± 572.57	25929.04 ^b ± 262.18	25368.37 ^b ± 71.68
Egg Mass (Kg)	2263.84 ^a ± 26.38	2278.59 ^a ± 36.64	1607.60 ^b ± 16.25	1623.57 ^b ± 4.59
FCR	2.266 ^{ab} ± 0.05085	2.226 ^b ± 0.04118	2.38 ^a ± 0.02082	2.38 ^a ± 0.018
FCR (Dozen egg)	1.74 ^{ab} ± 0.04	1.71 ^b ± 0.03	1.77 ^{ab} ± 0.017	1.83 ^a ± 0.015
Final Hen Wt. (Kg)	207 ^a ± 6.24	191.2 ^b ± 2.15	152 ^c ± 1.52	165.33 ^c ± 2.60
Total Feed Intake (Kg)	5787.34 ^a ±101.28	5730.50 ^a ±23.85	4494.01 ^b ±17.08	4603.79 ^b ±22.11

Means within the same row carrying different superscripts are significantly different (P ≤ 0.05).

Table 2 Effect of layer breeds on the economic indices of layer farms.

Items	Lohmann (LB)	ISA Brown	Hy-Line W-36	Hy-Line Brown
	----- Rearing stage -----			
Feed Cost (EGP)	5298.14 ^b ± 221.52	5316.43 ^b ± 25.22	5341.36 ^b ± 72.60	5881.71 ^a ± 31.63
TVC(EGP)	6998.14 ^b ± 221.52	7016.43 ^b ± 25.22	7041.36 ^b ± 72.60	7581.71 ^a ± 31.63
TC(EGP)	7048.14 ^b ± 221.52	7066.43 ^b ± 25.22	7091.36 ^b ± 72.60	7631.71 ^a ± 31.63
	----- Production Stage -----			
Feed Cost (EGP)	35875.52 ^a ± 544.36	35461.636 ^a ± 146.16	26784.3567 ^b ± 84.11	27080.05 ^b ± 130.38
TVC(EGP)	36375.52 ^a ± 544.36	35961.64 ^a ± 146.16	27284.36 ^b ± 84.11	27580.05 ^b ± 130.38
TC(EGP)	36525.52 ^a ± 544.36	36111.64 ^a ± 146.16	27434.36 ^b ± 84.11	27730.05 ^b ± 130.38
	----- Total -----			
Total feed cost (EGP)	41173.66 ^a ±733.67	40778.07 ^a ±169.92	32125.72 ^b ±126.46	32961.7533 ^b ±158.32
TVC(EGP)	43373.66 ^a ±733.67	42978.07 ^a ±169.92	34325.72 ^b ±126.46	35161.7533 ^b ±158.32
TC(EGP)	43573.66 ^a ± 733.67	43178.07 ^a ± 169.92	34525.72 ^b ± 126.46	35361.75 ^b ± 158.32

Means within the same row carrying different superscripts are significantly different (P ≤ 0.05).

Table 3 Effect of layer breeds on the profitability of layer farms.

Items	Lohmann (LB)	ISA Brown	Hy-Line W-36	Hy-Line Brown
Hen Sale (EGP)	3519 ^a ± 106.16	3250.4 ^b ± 36.62	2584 ^c ± 25.98	2810.67 ^c ± 44.26
Egg Return (EGP)	45984.29 ^a ± 535.97	46283.86 ^a ± 744.34	33707.75 ^b ± 340.84	32978.88 ^b ± 93.19
Total Return (EGP)	49573.29 ^a ± 575.32	49604.26 ^a ± 728.17	36361.75 ^b ± 318.62	35859.55 ^b ± 55.52
Net Profit (EGP)	5999.63 ^a ± 1141.56	6426.18 ^a ± 863.09	1836.03 ^b ± 214.86	497.79 ^b ± 100.46

Means within the same row carrying different superscripts are significantly different (P ≤ 0.05).

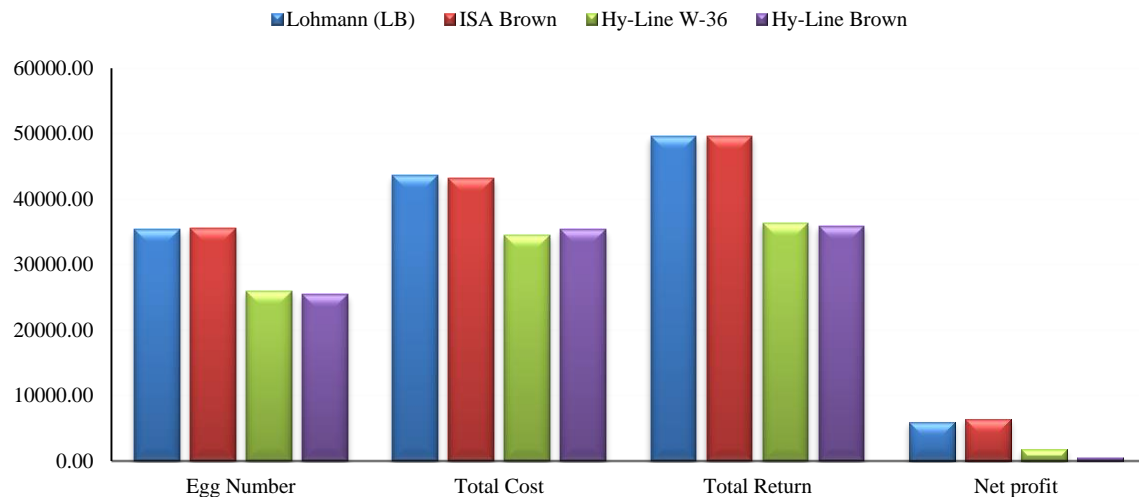


Chart 1 Profitability among the breeds of layer farms.

Concerning the hen sale, it was higher for brown breeds compared with the white breed due to the higher weight of the brown breeds, it significantly differed among the brown breeds as it was the highest for Lohmann (LB) (3519 EGP), followed by ISA Brown breed (3250.4 EGP), while it was the lowest for Hy-Line Brown (2810.67EGP) that increased non-significantly above the Hy-Line W-36 (2584 EGP) this result in agreement with Estrada Pareja and Restrepo Betancur (2015) who explained that the ISA Brown breed achieved better results for its weight and egg production. In responding to the egg return, total return, and net profit, they significantly differed among the four breeds, this result in

agreement with Eman et al. (2011) who found that the total return / 100 layers differed significantly among different Layer breeds, our results showed that they were the highest for ISA Brown breed (46283.86, 49604.26 & 6426.18 EGP, respectively) followed by the Lohmann breed (45984.29, 49573.29 & 5999.63 EGP, respectively), while it was the lowest for the Hy-Line Brown (32978.88, 35859.55 &497.79 EGP, respectively) that decreased non-significantly from the Hy-Line W-36 (33707.75, 36361.75 & 1836.03 EGP, respectively). These results might be due to the higher laying percentages that are associated with higher profitability (Ebraheem Althatat and AL-Sharafat, 2012).

This result is in the same line with Al-Khalifa and Ragheb (2013) who found that using the Lohmann brown eggs could compete with the imported products in terms of quality and price.

Regarding the efficiency measures that summarized in Table (4), the feed cost represents about 94.4% of the total costs for Lohmann and ISA Brown breeds, while it ranges from 93.05 to 93.2 % for Hy-Line W-36 and Hy-Line Brown, respectively. Concerning the egg return to TR, it significantly differed among the four breeds, this agreed with who concluded that it was the highest for ISA Brown breed 93.29% that increased significantly above Lohmann

and Hy-Line W-36 breeds (92.67 & 92.7%, respectively), while it was the lowest for Hy-Line Brown 91.69% this result disagreed with Holguín et al. (2019) who found that Hy-line Brown & ISA Brown breeds provide the same productive benefits.

Finally, The NP to TR % was the highest for ISA Brown and Lohmann (12.87 & 12.02%, respectively), followed by Hy-Line W-36 5.04%, while it was the lowest for Hy-Line Brown 1.39% this result agreed with Ripon Kumar Dutta (2012) who concluded that the cockerel of ISA Brown was the chicken that earned the maximum cost-benefit ratio (CBR).

Table 4 Effect of efficiency measures on the profitability of layer farms.

Items	Lohmann (LB)	ISA Brown	Hy-Line W-36	Hy-Line Brown
Feed cost/TC	94.48 ^a ±0.09	94.44 ^a ±0.02	93.05 ^b ±0.02	93.21 ^b ±0.03
TR/TC	113.94 ^a ±2.82	114.91 ^a ±2.06	105.32 ^b ±0.61	101.41 ^b ±0.58
Egg return/TR	92.76 ^b ±0.19	93.29 ^a ±0.14	92.70 ^b ±0.13	91.96 ^c ±0.13
NP/TR	12.02 ^a ±2.22	12.87 ^a ±1.50	5.04 ^b ±0.55	1.39 ^b ±0.2

Means within the same row carrying different superscripts are significantly different (P ≤ 0.05).

Table 5 Mortality percentage among the different layer breeds.

Items	Lohmann (LB)	ISA Brown	Hy-Line W-36	Hy-Line Brown
	----- Rearing Stage -----			
Mortality %	4.18 ^a ± 0.28	6.01 ^a ± 1.08	4.66 ^a ± 0.07	4.73 ^a ± 0.03
	----- Production Stage -----			
Mortality %	8.7 ^b ± 1.62	7.4 ^b ± 0.27	12.69 ^b ± 0.22101	12.16 ^b ± 0.09
	----- Total -----			
Total Mortality %	12.88 ^b ± 1.36	13.41 ^{ab} ± 1.35	17.3467 ^c ± 0.28	16.89 ^{ab} ± 0.06

Means within the same row carrying different superscripts are significantly different (P ≤ 0.05).

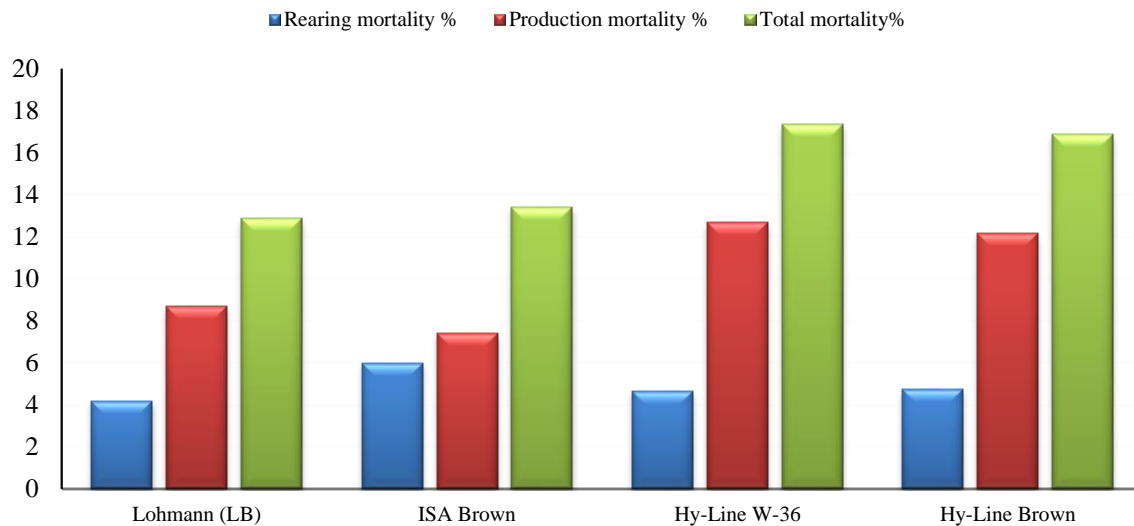


Chart 2 Mortality percentage among the four-layer breeds.

4. CONCLUSION AND RECOMMENDATION

The total feed intake, egg number, egg mass, FCR, FCR (dozen egg), and final hen weight differed significantly among different breeds, the highest feed intake and final hen weight were for Lohmann (LB) (5787.34 & 207 Kg/100 hens, respectively) and they were the lowest for Hy-Line W-36 (4494.01 & 152 kg/100 hens, respectively). The egg production significantly differed among the layer breeds it was the highest for ISA Brown breed (35603.97 eggs/100 birds/cycle), while it was the lowest for Hy-Line Brown breed (25368.37 eggs/100 hens), also ISA brown breed had the best FCR (2.22). The total return and net profit differed significantly among the layer breeds and they were the highest for ISA brown breed (49604.26 and 6426.18 EGP/100 birds, respectively), while they were the lowest for the Hy-Line Brown breed (35859.55 and 497.79 EGP/100 hens, respectively). Finally, we concluded that the ISA

Brown breed is the most profitable breed to be reared in the layer farms.

Our results emphasize the need for sufficient knowledge on poultry productivity and profitability to the government policymakers, producers, and marketers, which is essential for an integrated approach to genetically improved chicken breeds and strict bio-security poultry farming in our country.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

5. REFERENCES

1. Abd-El Hamed, A., Kamel, E., Abo-Salem, M., Atallah, S., 2017. Comparative Study on the Effect of Organic Acids, Prebiotics and Enzymes Supplementation on Broiler Chicks' Economic and Productive Efficiency. *Benha Journal of Applied Sciences* 2, 1-8.
2. Abd-ElHamed, A.M., Kamel, E.R., 2021. Effect of some non-genetic factors on the productivity and profitability of Holstein Friesian dairy cows. *Veterinary World* 14, 242-249.
3. Abdel-Wahed, H.M., 1998. The use of sorghum or rice bran in broiler and layer diets with reference to enzyme supplementation. Ph.D. Thesis, Agricultural Faculty, Cairo University, Fayoum.
4. Adegbenro, M., Ayeni, A., Olowoyeye, J., Bankole, O.M., Agbede, J.O., Onibi, G.E., Aletor, V.A., 2012. Leaf composite mix as alternative premix to commercial premix in broiler finisher diets, Conference on International Research on Food Security, Natural Resource Management and Rural Development. Organised by Georg-August Universität Göttingen and University of Kassel-Witzenhausen, pp. 1-4.
5. Al-Khalifa, H., Ragheb, G., 2013. Enhancing diversity of poultry products by producing high quality brown eggs. *European Scientific Journal* 9, 230-240.
6. Anene, D.O., Akter, Y., Thomson, P.C., Groves, P., O'Shea, C.J., 2020. Variation and Association of Hen Performance and Egg Quality Traits in Individual Early-Laying ISA Brown Hens. *Animals* 10, 1601-1614.
7. Atallah, S., 1994. Economic and productive efficiency of veterinary therapy in poultry farms. MV Sc. Thesis, Faculty of Veterinary Medicine, Alexandria University, Egypt.
8. Atallah, S., 2000. Study the economic and productive efficiency of some broiler farms in relation to ration constituents. *Minoufyia Veterinary Journal* 1, 69- 83.
9. Bogale, A., Edae, C., 2020. Review on Productive and Reproductive Performance of Exotic Chicken Breed in Ethiopia.
10. Dutta, R.K., Islam, M.S., Kabir, A., 2012. Assessment of the production performance and economic efficiencies of available chicken breeds (*Gallus domesticus* L.) in Rajshahi, Bangladesh. *University Journal of Zoology. Rajshahi University* 31, 13-18.
11. Ebraheem Althahat, AL-Sharafat, A.J.B., 2012. Factors Affecting Profitability of Layer Hens Enterprises. *American Journal of Agricultural and Biological Sciences* 7, 106-113.
12. Eman, R., Kamel, Bakry, H., Atallah, S., 2011. Some factors affecting economic and productive efficiency of layer production farms. *Faculty of veterinary medicine journal, Zagazig University*.
13. Estrada Pareja, M.M., Restrepo Betancur, L.F., 2015. Characterization of production parameters for genetic lines of ovipositors in a high tropical zone. *Revista Lasallista de Investigación* 12, 46-57.
14. Feltwell, R., 2011. *Small-Scale Poultry Keeping: A Guide to Free-Range Poultry Production*. Faber & Faber.
15. Hinsemu, F., Hagos, Y., Tamiru, Y., Kebede, A., 2018. Review on challenges and opportunities of poultry breeds. *Journal Dairy Veterinary Science* 7, 1-9.
16. Holguín, S.P., Terranova, V.A.T., Alexandra, Y., Erazo, P., 2019. Comparación de parámetros productivos de las líneas genéticas Hy-line Brown, Isa Brown, Babcock Brown en granja avícola la reserva. Universidad Tecnológica de Pereira. Facultad de Ciencias de la Salud <https://hdl.handle.net/11059/11383>.
17. Iannotti, L.L., Lutter, C.K., Bunn, D.A., Stewart, C.P., 2014. Eggs: the uncracked potential for improving maternal and young child nutrition among the world's poor. *Nutrition reviews* 72, 355-368.
18. Islam, M.S., Kabir, A., 2021. Productivity of Chicken Breeds: Scenarios in Northern Bangladesh. LAP Lambert Academic Publishing, Germany, available at SSRN: <https://ssrn.com/abstract=3844441> or <http://dx.doi.org/10.2139/ssrn.3844441>
19. Kamel, E.R., 2016. Comparative study of crossbred chickens. *International Journal of Current Research* 8, 30613-30619.
20. Miranda, J.M., Anton, X., Redondo-Valbuena, C., Roca-Saavedra, P., Rodriguez, J.A., Lamas, A., Franco, C.M., Cepeda, A., 2015. Egg and egg-derived foods: effects on human health and use as functional foods. *Nutrients* 7, 706-729.
21. North, M.O., 1984. *Commercial chicken production manual*. Commercial chicken production manual 2nd Edn. Av. Publishing company, Inc Westpost Connecticut, USA.
22. Rafeeq, M., Rashid, N., Awan, M., Tariq, M., Abbas, F., Ahmed, Z., Taj, I., 2013. Effect of Forced Molting on body characteristics and post-molting egg production performance of Layers in Quetta, Pakistan. *Brazilian Journal of Poultry Science* 15, 347-351.
23. Rakonjac, S., Dosković, V., Bošković, S., Škrbić, Z., Lukić, M., Petričević, V., Petrović, D., 2021. Production Performance and Egg Quality of Laying Hens as Influenced by Genotype and Rearing System. *Brazilian Journal of Poultry Science* 23, 1-8.
24. Rayan, G., Mahrous, M., Galal, A., El-Attar, A., 2013. Study of some productive performance and egg quality traits in two commercial layer strains. *Egyptian Poultry Science Journal* 33, 357-369.
25. Ripon Kumar Dutta, M.S.I.a.M.A.K., 2012. Assessment of the production performance and economic efficiencies of available chicken breeds (*Gallus domesticus* L.) in Rajshahi, Bangladesh. *University Journal, Rajshahi University Zoological Society* 31, 13-18.
26. Sallam, E.A., Mohammed, L.S., Azam, A.E., 2019. Factors Affecting Productive and Economic Efficiency of Hy-Line Layer Breed Under Egyptian Condition. *Alexandria Journal for Veterinary Sciences* 63, 14-22.
27. Singh, M., Groves, P., 2020. Welfare implications for barn (and aviary) egg production systems. *Animal Production Science*. 61, 837-847. <https://doi.org/10.1071/AN19634>
28. Singh, R., Cheng, K., Silversides, F., 2009. Production performance and egg quality of four strains of laying hens kept in conventional cages and floor pens. *Poultry science* 88, 256-264.
29. Singh, V., Pathak, V., Akhilesh, K.V., 2012. Modified or enriched eggs: A smart approach in egg industry. *American Journal of Food Technology* 7, 266-277.
30. Sørensen, P., 2001. Breeding strategies in poultry for genetic adaptation to the organic environment, Breeding and feeding for animal health and welfare in organic livestock systems, *Proceedings of the Fourth Nahwoa Workshop*, pp. 51-62.
31. Sosnowka-Czajka, E., Herbut, E., Skomorucha, I., Muchacka, R., 2011. Welfare levels in heritage breed vs. commercial laying hens in the litter system. *Annals of Animal Science* 11, 585-595.
32. SPSS, I., 2015. *SPSS for Windows (Version 23)* Chicago, Illinois: SPSS, Inc.
33. Tolimir, N., Mašić, B., 2000. The results of European egg production tests in 1997-1998. *Živinarstvo* 35, 66-68.
34. Xin, H., Burns, R.T., Arthur, J., Roberts, S.A., 2006. Laying Hen Manure Characteristics and Air Emissions as Affected by Genetic Strains. *Agricultural and Biosystems Engineering Technical Reports and White Papers* 1-11. http://lib.dr.iastate.edu/abe_eng_reports/4.
35. Yigzaw, M., Demeke, S., Hassen, W., 2021. Egg production performance of three strains of laying hens kept in floor pens. <https://doi.org/10.21203/rs.3.rs-1026950/v1>.