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Economic and productive efficiency analysis for meat chicken breeds under different management systems

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ABSTRACT

The managemental and environmental factors had an impact on the efficiency of broiler production, so our study aimed to inspect the influence of market age, season, and stocking density within various breeds on productive and economic efficiency. Several cycles of variants broiler breeds (Cobb, Ross, Arbor acres, Avian, and Indian river) were collected from EL-Kaliobia, EL-Dakahlia, and EL-Menofia, about 115 cycles between 2021 to 2022. Our results showed that the Indian River breed recorded the highest feed intake (FI), average daily feed intake (ADFI), feed conversion rate (FCR), feed cost, total variable cost (TVC), and total cost (TC). They recorded the lowest gross margin (GM) and net profit (NP). Concerning marketing age, the body weight (BW), body weight gain (BWG), feed intake (FI), feed cost, total variable cost (TVC), total cost (TC), total return (TR), gross margin (GM), and net profit (NP) increased as market age increased. while average daily gain (ADG) and average daily feed intake (ADFI) decreased gradually as market age increased. The season significantly affected ADG and ADFI increased in winter compared to summer, while gross margin increased in summer compared to winter. birds raised at stocking density 9-11 birds/m^2 showed higher body weight yield, BWG yield, FI, feed cost, TVC, TC, bird selling, and TR than birds raised at lower stocking density. So, it could be concluded that breeds, marketing age, season, and stocking density all significantly impact the profitability and performance of broiler chickens in Egypt.

Introduction

Poultry farming is currently one of the main rural industries that offers a variety of job opportunities to the community and contributes to improving nutritional status, food security, and decreasing poverty (Ali *et al*., 2015). Chicken meat has less fat and cholesterol, so it is regarded as a healthier choice than red meat (Ikusika *et al*., 2020). There was an annual increase in consumption of chicken products by 5.8% over the past decade leading to increased demand for them (Parveen *et al*., 2016). Poultry farming can provide at least this portion of demand by improving output and reducing losses (El-Tahawy *et al*., 2017). In most nations throughout the world, poultry is an essential supply of animal protein for the human population and genetically modified strains of the bird have greatly enhanced the development of the poultry sector, progress in environmental management, food & health has also contributed to better performance (Mckay, 2009).

The production and livability of broiler strains may be greatly impacted by some environmental conditions that can cause the productivity of these strains to vary greatly (Al-Dawood, 2016). In the poultry sector, chickens are subjected to stressors, including climate, stocking density, and humidity (Son *et al*., 2022). The primary impact on broiler performance, health, and physiology was caused- by seasonal changes in ambient temperatures (Hassan and Reda, 2021). Additionally, the season may noticeably impact the amount of ration utilized during broiler rearing (Attallah *et al*., 1997). Exposure of broiler to extremely high temperatures resulted in reduced feed utilization as an attempt to maintain homeothermy and reduce metabolic heat production (Abu-Dieyeh, 2006). On the other hand, low ambient temperatures improve feed consumption, body weight gain, feed efficiency & livability of chickens (Ali *et al*., 2015). Therefore, selecting the best time of year to raise broilers is essential to maximizing output (Koknaroglu and Atilgan, 2007).

Additionally, the duration of the production cycle and when to decide to market broilers are essential, particularly when productivity and product quality are considered (Abougabal and Taboosha, 2020). Several elements influence the marketing age, including the market demand for chicken products, mortality rates, flock size, environmental circumstances, and the farm's hygienic standards (Kamruzzaman *et al*., 2021).

Broiler welfare, health, as well as productivity, are directly affected by stocking density

, making it one of the most significant issues in broiler production (Buijs *et al*., 2009). As per Goo *et al*. (2019), When the stocking density is excessive (18 birds/m^2), more chickens are produced per the same stocking area, frequently employed to improve profitability. On the other hand, Ammonia production, footpad irritation, litter humidity, stress, and cleaning are all consequences of increased stocking density in the broiler litter flooring system (McKeith *et al*., 2020). Thus, our research inspected the influence of market age, season, and stocking density within various breeds on productive and economic efficiency.

Materials and methods

Several cycles of variants broiler breeds (Cobb, Ross, Arbor acres, Avian, and Indian river) were collected from EL-Kaliobia, EL-Dakahlia, and EL-Menofia, about 115 cycles during the period between 2021 to 2022, and studied under ethical number (BUFVTM 48-12-24).

The data was gathered from records found in poultry farms in research areas using structured questionnaires (Koknaroglu and Atilgan, 2007; Ali *et al*., 2015). Data were classified based on breed into Cobb (n.=31), Ross (n.= 25), Arbor acres (n.= 24), Avian (n.= 19) and Indian river (n.= 16). According to the marketing age, 30-35 days (n.= 25), 36-40 days (n.= 64), 41-45 days (n.= 26). Based on season, summer (n.= 68) and winter (n.= 47). Stocking density was classified into 4-9 bird/m^2 (n.= 47), >9-11 bird/m^2 (n.= 18) and over 11 bird/m^2 (n.= 50).

Kinds of gathered data

Productive efficiency data, which included breed, initial and final weight, Chicken's number at the beginning and end of the cycle, and amount of feed intake.
Environmental and managemental data included market age, stocking density, and season of rearing.
Economic data included cost of kg feed and price of kg meat, cost of drugs, vaccines, and disinfectants, price of feeders, drinkers, cost of electricity and water, cost of litter, salary of veterinarian, price of chicks, and farm rent.

Data calculation

Productive and economic efficiency calculations

Productive efficiency measures: body weight gain (BWG) and feed intake (FI) were calculated according to Aya *et al*. (2018). Feed conversion rate (FCR) and average daily gain (ADG) were computed according to Kamel *et al*. (2020). ADFI was calculated as described by Ahmed *et al*. (2024). According to Vetter and Matthews (1999), the mortality rate was measured.

Economic efficiency measures

Cost parameters were computed as indicated below:
Total cost (TC)=TFC+TVC (Tom, 2002), Total variable cost (TVC), measured in Egyptian pounds, includes feed consumption, labor, chick price, water, power, and litter expenditures (Bano *et al*., 2011). Total fixed cost (TFC) includes buildings and equipment depreciation (Amarapurkar *et al*., 2014).

Return parameters

Total return (TR) was calculated according to Omar (2014). Net profit (NP) was computed as per Abudabos *et al*. (2018). According to Onsongo *et al*. (2018), the gross margin (GM) was calculated.

Productive and Economic efficiency measures/m^2 were measured (Aya *et al*., 2018) as follow:
Yield of live body weight per m^2=Stocking density×Final BW per bird
BWG per m^2=Stocking density×BWG per bird
Total feed amount per m^2=Stocking density×Total feed amount per bird
TC per m^2=Stocking density×TC per bird
TR per m^2=Stocking density×TR per bird
NP per m^2=Stocking density×NP per bird

Data analysis

SPSS Version 26.0 (SPSS, 2019) was utilized to gather, organize, condense, and interpret data using a multivariant general linear model (GLM) for determination of the influence of marketing age, season & stocking density within different breeds on studied variables.

Results

Table 1 shows productive and economic efficiency parameters among different breeds. Variant breeds differ significantly in FI, ADFI, FCR, feed cost, TVC, TC, and the gross margin and profit, while non-significantly differ in initial weight, final weight, BWG, and TR. Indian River recorded the highest FI, ADFI, FCR, feed cost, TVC, and TC, on the other hand, it recorded the lowest gross margin and profit.

Table 2 revealed that BW, BWG, FI, feed cost, TVC, TC, TR, GM, and NP were increased gradually as market age increased. Additionally, birds marketed at 41-45 d had the highest values. While ADG and ADFI decreased gradually as market age increased, and their highest values were recorded for birds marketed at 30-35 d.

Table 3 demonstrated that season has a non-significant effect on initial weight, final weight, BWG, FI, FCR, feed cost, TVC, TC, bird selling, TR, and NP. While ADG and ADFI were significantly increased in winter compared to summer, the gross margin increased in summer compared to winter.

Table 4 shows that birds raised at stocking density 9-11 birds/m^2 showed higher body weight, BWG, FI, feed cost, TVC, TC, bird selling, and TR than birds raised at lower stocking density.

Figure 1 indicates productive and economic efficiency parameters

Table 1. Impact of various breeds on broiler chickens' productivity and economic efficiency measures.

Parameters	Breed					P value
	Cobb	Ross	Arbor acres	Avian	Indian river	
Initial weight	41.16±0.18	41.08±0.22	41.38±0.27	41.11±0.2	41.31±0.24	NS
Final BW	2106.32^a±19.59	2215.6^a±31.47	2171.04^a±28.41	2157.53^a±42.16	2204.38^a±38.2	NS
BWG	2065.16±19.59	2174.52±31.54	2129.67±28.44	2116.42±42.1	2163.06±38.21	NS
ADG	56.54±0.58	56.48±0.63	59.15±1.27	58.14±0.92	56.01±1.35	NS
FI	3027.51^c±23.47	3251.82^b±56.24	3105.23^{bc}±31.42	3104.2^c±48.91	3426.49^a±46.58	<0.001
FCR	1.47^b±0.02	1.49^b±0.02	1.46^b±0.02	1.47^b±0.02	1.59^a±0.03	<0.001
ADFI	81.48^b±1.29	82.81^{ab}±1	84.43^{ab}±1.17	83.95^{ab}±1.89	86.97^a±1.62	<0.001
Feed cost	31.79^c±0.25	34.14^b±0.59	32.6^{ac}±0.33	32.59^c±0.51	35.98^a±0.49	<0.001
Total veterinary management (TVM)	4.75±0.6	5.85±0.63	5.41±0.93	5.82±0.59	7.27±0.68	NS
TVC	46.39^b±0.82	48.98^b±0.78	47.47^b±0.89	47.18^b±1.46	54.05^a±0.96	<0.001
TFC	1.4±0.11	1.13±0.05	1.09±0.04	1.18±0.13	1.29±0.14	NS
TC	47.79^b±0.87	50.11^b±0.8	48.56^b±0.89	48.36^b±1.54	55.34^a±0.91	<0.001
Bird selling	63.19±0.59	66.47±0.94	65.13±0.85	64.73±1.26	66.13±1.15	NS
Litter sale/ chick	0.72±0.06	0.53±0.02	0.53±0.06	0.55±0.05	0.63±0.05	NS
Total return	63.91±0.63	67.00±0.96	65.66±0.84	65.28±1.26	66.76±1.14	NS
Gross margin	17.52^a±0.91	18.02^a±0.84	18.19^a±1.09	18.10^a±1.81	12.71^b±1.04	<0.001
Net Profit	16.12^a±0.97	16.89^a±0.85	17.10^a±1.08	16.92^a±1.88	11.42^b±1.02	<0.001

(a-b-c) in a single row, the mean of several breeds with distinct superscripts differed significantly at (P≤0.05).
BW: body weight, BWG: body weight gain, ADG: average daily gain, FI: feed intake, FCR: feed conversion rate, ADFI: average daily feed intake, TVC: total variable cost, TFC: total fixed cost, TC: total cost.

Table 2. Impact of different marketing ages on broiler chickens' productivity and economic efficiency measures.

Parameters	Market age			P Value
	30-35	36-40	41-45	
Initial weight	41.16±0.21	41.25±0.14	41.12±0.21	NS
Final BW	2079.16[c]±32.88	2156.78[b]±14.89	2270.81[a]±28.56	<0.001
BWG	2038[c]±32.88	2115.53[b]±14.87	2229.69[a]±28.66	<0.001
ADG	60.87[a]±0.92	57.25[b]±0.45	53.81[c]±0.72	<0.001
FI	3014.65[c]±32.64	3162.08[b]±28.05	3297.61[a]±47.77	<0.05
FCR	1.47±0.02	1.49±0.01	1.48±0.02	NS
ADFI	88.26[a]±0.81	83.96[b]±0.83	78.04[c]±0.92	<0.001
Mortality %	5.26[a]±0.6	6.69[a]±0.79	5.58[a]±0.56	NS
Feed cost	31.65[c]±0.34	33.2[b]±0.29	34.62[a]±0.5	<0.05
Total veterinary management (TVM)	4.7±0.65	6.15±0.45	5.36±0.61	NS
TVC	47.07±0.92	48.27±0.66	49.87±1.05	NS
TFC	1.36±0.13	1.21±0.06	1.12±0.06	NS
TC	48.43±0.97	49.48±0.67	50.99±1.08	NS
Bird selling	62.37[c]±0.99	64.7[b]±0.45	68.12[a]±0.86	<0.001
Litter sale/ chick	0.54[b]±0.05	0.58[ab]±0.03	0.7[a]±0.06	<0.05
Total return	62.91[c]±0.96	65.28[b]±0.45	68.82[a]±0.87	<0.001
Gross margin	15.84[b]±1.12	17.01[ab]±0.63	18.95[a]±1.31	<0.01
Net Profit	14.48[b]±1.16	15.80[ab]±0.65	17.83[a]±1.33	<0.01

(a-b-c) in a single row, the mean of several marketing ages with distinct superscripts differed significantly at (P≤0.05).
B: breed, M: market age, B*M: breed x market age. BW: body weight, BWG: body weight gain, ADG: average daily gain, FI: feed intake, FCR: feed conversion rate, ADFI: average daily feed intake, TVC: total variable cost, TFC: total fixed cost, TC: total cost.

Table 3. Impact of various seasons on broiler chickens' productivity and economic efficiency measures.

Parameters	Season		P value
	Summer	Winter	
Initial weight	41.19±0.13	41.21±0.16	NS
Final BW	2170.51[a]±16.8	2158.7[a]±24.16	NS
BWG	2129.32±16.82	2117.49±24.16	NS
ADG	56.46[b]±0.41	58.42[a]±0.82	<0.05
FI	3156.22±26.28	3167.12±38.27	NS
FCR	1.48±0.01	1.49±0.02	NS
ADFI	82.17[b]±0.77	85.55[a]±0.99	<0.01
Mortality %	6.69[a]±0.74	5.31[a]±0.44	NS
Feed cost	33.14±0.28	33.25±0.4	NS
Total veterinary management (TVM)	5.72±0.46	5.55±0.41	NS
TVC	47.7±0.6	49.35±0.79	NS
TFC	1.26±0.06	1.17±0.06	NS
TC	48.96±0.62	50.52±0.81	NS
Bird selling	65.12±0.5	64.76±0.72	NS
Litter sale/ chick	0.64±0.03	0.55±0.04	NS
Total return	65.76±0.51	65.31±0.73	NS
Gross margin	18.06[a]±0.68	15.96[b]±0.8	<0.05
Net Profit	16.80±0.7	14.79±0.82	NS

(a-b-c) in a single row, the mean of several seasons with distinct superscripts differed significantly at (P≤0.05).
B: breed, S: season, B*S: breed x season. BW: body weight, BWG: body weight gain, ADG: average daily gain, FI: feed intake, FCR: feed conversion rate, ADFI: average daily feed intake, TVC: total variable cost, TFC: total fixed cost, TC: total cost.

per m^2. The total amount of BW, BWG, FI, TC, TR, and NP increased gradually as stocking density increased. The highest values were recorded by birds raised at a stocking density above 11 birds/m^2, and the lowest values were recorded at the lowest stocking density.

Discussion

There is a higher demand for broiler meat because customers are looking for high-quality feeds that are low in fat and rich in protein (Nasr *et al.*, 2021). Within the current study, we examined the effect of various breeds, marketing age, seasons, and stocking density to detect which has the least negative impact on broiler health, production, and profit. As presented in Table 1, the Indian river recorded the significantly highest FI, ADFI, FCR, feed cost, TVC, and TC, and recorded the lowest gross margin and profit, Variant breeds non-significantly differ in initial weight, final weight, BWG, and TR. Our results matched Aya *et al.* (2018) who mentioned that the Indian river breed had lower NP than the Cobb and Ross breeds. Indian river breed showed higher FI, FCR, feed cost, TVC, and

Table 4. Impact of various stocking densities on broiler chickens' productivity and economic efficiency measures.

Parameters	Stocking density			P value
	4-9 bird/m^2	>9-11 bird/m^2	Over 11 bird/m^2	
Initial weight	41.28±0.14	40.83±0.2	41.26±0.17	NS
FBW	2129.79^{b}±19.03	2249.72^{a}±37.52	2169.18^{ab}±21.66	<0.05
BWG	2088.51±19.03	2208.89±37.55	2127.92±21.66	NS
ADG	56.34±0.52	58.27±0.94	57.77±0.75	NS
FI	3076.79^{b}±29.45	3253.12^{a}±69.85	3206.25^{a}±31.03	<0.05
FCR	1.47±0.02	1.47±0.01	1.51±0.01	NS
ADFI	81.49^{b}±1	84.15^{ab}±1.46	85.28^{a}±0.89	≤0.001
Mortality %	5.59±0.35	5.56±0.5	6.83±1.02	NS
Feed cost	32.31^{b}±0.31	34.16^{a}±0.73	33.67^{a}±0.33	<0.05
Total veterinary management (TVM)	4.5^{b}±0.34	6.86^{a}±1.05	6.3^{a}±0.52	<0.001
TVC	46.97^{b}±0.78	50.1^{a}±1.34	49.07^{ab}±0.66	<0.01
TFC	1.3^{a}±0.1	0.91^{b}±0.04	1.27^{a}±0.03	<0.05
TC	48.27^{b}±0.81	51.01^{a}±1.33	50.34^{ab}±0.67	<0.01
Bird selling	63.89^{b}±0.57	67.49^{a}±1.13	65.08^{ab}±0.65	<0.05
Litter sale/ chick	0.71^{a}±0.05	0.48^{b}±0.04	0.54^{b}±0.03	<0.05
Total return	64.6^{b}±0.59	67.97^{a}±1.16	65.62^{ab}±0.65	<0.05
Gross margin	17.63±0.97	17.87±1.16	16.55±0.67	NS
Net Profit	16.33±1.01	16.96±1.14	15.28±0.69	NS

(a-b-c) in a single row, the mean of several stocking densities with distinct superscripts differed significantly at (P≤0.05).
B: breed, SD: stocking density, B*SD: breed x stocking density. BW: body weight, BWG: body weight gain, ADG: average daily gain, FI: feed intake, FCR: feed conversion rate, ADFI: average daily feed intake, TVC: total variable cost, TFC: total fixed cost, TC: total cost.

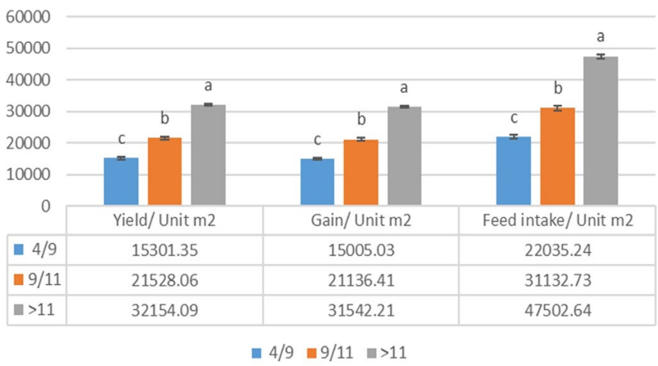

Figure 1. Impact of various stocking densities on broiler chickens' productivity measures (gm per m^2).

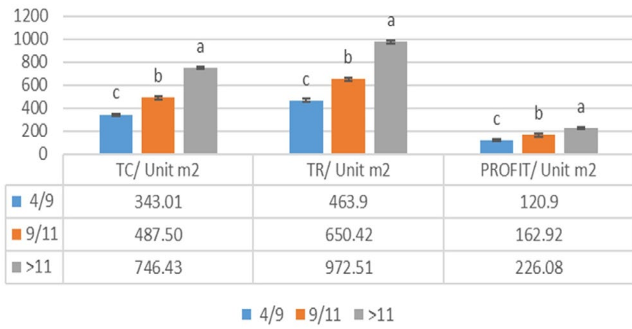

Figure 2. Impact of various stocking densities on broiler chickens' economic efficiency measures (LE per m^2).

TC, while lower NP than the Cobb breed (Mohammed *et al*., 2021). The highest feed cost was recorded in the Indian river breed compared to the ross breed (Ghanima *et al*., 2023). Indian river breed had higher FI, FCR, and feed costs than the Cobb breed (Abd-El Hamed *et al*., 2017). On the other hand, the Indian breed had the lowest value of feed intake and FCR, feed cost, and highest initial weight, TR compared to Hubbard, Ross, and Cobb breeds (Aya *et al*., 2018).

The marketing age is very necessary for growth performance and economic efficiency, but the issue is that different producers and farmers have different marketing days since some farmers think it is more profitable to sell their birds as soon as possible (Rehab, 2017). However, the smaller birds are unlikely to provide the highest-quality meat, which impacts both pricing and the attitudes of the consumers (Abougabal and Taboosha, 2020). The current research indicated that BW, BWG, FI, feed cost, TVC, TC, TR, GM, and NP increased gradually as the market age increased. Additionally, birds marketed at 41-45 d recorded the highest values. while ADG and ADFI decreased gradually as market age increased and the highest value on birds marketed at 30-35 d. The increase in TR and NP may be due to older birds having higher body weight than younger chickens and a direct correlation exists between BW and sales of broilers that indicates TR & NP (Shehata *et al*., 2021). Our outcomes match with (Shehata and Elsokary, 2024) who revealed that increasing market age led to a significant rise in BW, BWG, FI, TR, and feed costs. Faria *et al*. (2022) cleared that increasing marketing age increased final BW and BWG. According to Baéza *et al*. (2011), higher marketing ages directly impact profit since they provide producers with more meaty birds. On the other hand, Shehata and Elsokary (2024) mentioned that the market age did not significantly affect net profit.

Seasonal fluctuations and climatic changes are important nongenetic elements affecting the profitability and performance of broilers (El-Faham *et al*., 2017). Our research observed that season had a non-significant effect on initial weight, final weight, BWG, FI, FCR, feed cost, TVC, TC, bird selling, TR, and NP. While ADG and ADFI increased in winter compared to summer, the gross margin increased in summer compared to winter. These results agreed with Hassan and Reda (2021) who stated that the season had no significant impact on FI and initial weight. Moreover, FCR did not differ significantly in summer and winter (Koknaroglu and Atilgan, 2007). Additionally, the season did not affect broiler weight (Thirumalesh *et al*., 2012). Conversely, Ali *et al*. (2015) revealed that BW and NP increased in the winter compared to the summer season, but FI and FCR significantly increased in summer compared to winter. The winter season had improvement in BW, BWG, TC, and TVC compared to the summer season in Hubbard, Ross, and Indian River so the winter season had more TR and NP than the summer (Aya *et al*., 2018).

Stocking density is a vital welfare element that directly and indirectly influences chicken's growth performance (Skrbic *et al*., 2009). So, this study concentrated on this aspect of broiler production's economic efficiency and performance (El-Tahawy *et al*., 2017). Our results revealed that birds raised at stocking density 9-11 birds/m^2 showed higher body weight yield, BWG yield, FI, feed cost, TVC, TC, bird selling, and TR than birds raised at lower stocking density. Our findings matched with Feddes *et al*. (2002) and Aya *et al*. (2018) who revealed that higher values of BW and BWG were observed in higher stocking density. Shehata *et al*. (2022) observed that increased stocking density led to increased feed intake of broiler chickens. Higher stocking density improved total return (Ghosh *et al*., 2012). Conversely, Shehata *et al*. (2022) mentioned that increased stocking density resulted in decreased BW, BWG, TR, NP, and bird sales. Liu *et al*. (2021) and Son *et al*. (2022) confirmed that BW, BWG, and FI decrease with increased stocking density.

As shown in figure1, productive and economic efficiency measures per m^2. The total amount of BW, BWG, FI, TC, TR, and NP increased gradually as stocking density increased and the highest value was found on birds raised on stocking density above 11 bird/m^2 and the lowest value on the lowest stocking density. Our results agreed with Feddes *et al*. (2002) who found that stocking density affected output kg/m^2, which increased with higher stocking densities.TC, TR, and NP increase when there are more birds per unit area (Aya *et al*., 2018). If there were more birds per unit area, the total return increased as well (Estevez, 2007).

Conclusion

This research revealed that breed, marketing age, season, and stocking density are necessary elements that affect broiler chicken production and profitability in Egypt. Profit shows the highest level in arbor acres breed, increasing marketing age results in increases of body weight, total return, and net profit. Summer season shows an increase in gross margin than winter season. Birds that reared in stocking density 9-11 bird/m^2 have the highest body weight and total return.

Conflict of interest

The authors have no conflict of interest to declare.

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