Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X 2022 / v.24 / n.2 / 001-008

http://dx.doi.org/10.1590/1806-9061-2021-1534

Original Article

A Comparative Study on Growth Parameters of Three Broiler Chicken Strains from Jordan

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■Keywords

Growth performance; physiology; poultry; subtropics; welfare.

Submitted: 14/July0/2021
Approved: 03/November/2021

ABSTRACT

The development of the poultry industry in the last years demanded the evaluation of different broiler chicken strains in order to improve production efficiency and welfare, considering physiological and livability parameters. Thus, the present study aimed to compare the growth performance and the livability of three broiler strains (Lohmann, Hubbard and Ross). All birds were fed a similar standard commercial diet *ad libitum*, and were separately allocated to three treatment groups. Live body weight (LBW) and body weight gain (BWG) were weekly recorded. Feed intake (FI), feed conversion ratio (FCR), and livability (%) were calculated at the end of the experiment. The mean weekly LBW increased significantly in all broiler strains ($p<0.05$). The mean final LBW (kg/bird) of birds was significantly ($p<0.05$) higher in Hubbard (1.81±0.20) and Ross (1.80±0.18) than in Lohmann (1.69±0.06). Mean total BWG (kg/bird) was also significantly ($p<0.05$) higher in Hubbard (1.67±0.20), and Ross (1.64±0.18) than in Lohmann (1.54±0.06). Broiler strain had no significant effect on total FI and FCR. FCR values were 2.20±0.40, 2.21±0.53 and 2.44±0.65 g feed/g gain in Hubbard, Lohmann, and Ross, respectively. The livability of the three strains did not show any significant differences among the treatment groups, with values of 95.13% (Ross), 95.64% (Lohmann), and 92.94% (Hubbard). In conclusion, the present findings indicated that production performance of broiler chickens are considerably affected by their strains, and Hubbard achieved greater LBW, and BWG and the best FCR as compared to the Lohmann, and Ross strains.

INTRODUCTION

The poultry industry has played a significant role among agricultural industries in many countries worldwide (Abu-Dieyeh, 2006; Al-Fataftah & Abdelqader, 2013; Al-Dawood, 2016). Chicken meat represents a cheap and good protein source with lower cholesterol content when compared with red meat. Additionally, egg production, short productive lifespan, absence of dietary restriction, and global distribution have all favored the use of poultry products as a significant source of animal protein (Davison *et al.*, 2008; Al-Ruwaili *et al.*, 2014; Husna *et al.*, 2017). Moreover, the poultry industry as micro-livestock is recognized as the most popular emerging industry in the world, contributing meat, eggs and other food products (Hossain *et al.*, 2011). According to the poultry world association, a person consumes 3.63 kg/year of poultry meat, and the consumption is expected to be 12 kg/year by 2021 (Husna *et al.*, 2017). In Jordan, the broiler production industry has developed very fast in the last few decades, and it has become one of the most essential sectors in the animal production industry contributing to employing workforce. Its revenue is the primary source of income for agricultural holders. The Jordanian total production of chicken meat is 291,538 metric tons, with a self-sufficiency ratio of 74.9% (Jordan Statistical Yearbook, 2016).

The most significant scientific and technological development of the poultry industry in the last years demanded the investigation of different broiler strains to improve production efficiency and disease resistance (Alshawabkeh & Tabbaa, 2001; Zakaria *et al.*, 2009; Hossain *et al.*, 2011). Thus, various broiler strains have been developed in the past years to obtain maximum meat production. Growth curve functions are the adequate means for describing the growth pattern of live body weight (LBW). They summarize the information into a few parameters that may be interpreted biologically (Goliomytis *et al.*, 2003). Feed conversion ratio (FCR) measures how well a flock converts feed intake into LBW. It provides an indicator of management performance and also profit at any given feed cost. Feed cost is the major component of the variable cost, accounting for ~70% of the total cost (Waller, 2007). During the past years, research on poultry has mainly focused on growth rate and FCR (Samarakoon & Samarasinghe, 2012). Addtionally, the body weight gain (BWG) of the broiler strains has been markedly increased, and the FCR has been enormously improved with the advancement of new technology applied in poultry nutrition and genetics (Hossain *et al.*, 2011; Husna *et al.*, 2017). This progress in breeding and food has resulted in broiler strains having a higher performance today than ever before.

The continuous effort of breeders towards producing high-quality broiler strains with improved production and physiological traits demands continuing evaluation and selection of broiler strains. However, various characteristics of broiler strains such as production potentials, resistance to disease incidences, marketing age, consumer demand, meat quality, profitability, and adaptability may adversely affect farmers' preference and profit margin of rearing broiler strains. The productivity of these strains may vary significantly due to several environmental factors and other incidences, which may have significant impact on the production potentials and livability of broiler strains (Alshawabkeh & Tabbaa, 2001; Zakaria *et al.*, 2009; Ghazi *et al.*, 2012; Sohail *et al.*, 2012; Al-Fataftah & Abdelqader, 2013; Al-Dawood & Büscher, 2014; Al-Dawood, 2016).

To determine how animal welfare will be positively or negatively affected, many criteria could be used, i.e. behavior, production performance, and physiology parameters. In particular, the production factors and livability have been used as indicators of chicken welfare (Anderson *et al.*, 2004). Traditionally, the most important criteria for evaluating the performance of broiler strains have been the growth rate, FCR, and carcass composition (Smith & Pesti, 1998; Rezaei *et al.*, 2004). Better production performance and higher bird livability rate are significant features of positive welfare in poultry (Dawkins *et al.*, 2004; Mashaly *et al.*, 2004; Adeniji, 2012). The depression in live LBW and BWG might be due to decreasing feed consumption, inefficient digestion, impaired metabolism, the genetic make-up of birds, and temperature (Tona *et al.*, 2004). Thus this depression will lower both the market age and the production costs of chickens. To start a poultry farm successfully, more emphasis should be given to the quality of day old chicks. Typically, the heavier the broiler day-old chick is, the quicker is BWG, and the higher is profitability (Rahimi *et al.*, 2006). Also, low livability is costly and thus indicates management failure.

Despite the tremendous growth and development of modern broiler strains worldwide, the inadequate supply of quality animal protein is still the main problem for people worldwide. Given the above considerations and to improve the productivity of broiler chicken, the present study has been designed for comparing the growth performance and livability of three broiler strains (Lohmann, Hubbard, and Ross) in Jordan. The current findings might be utilized in the breeding soundness assessment to select the correct broiler strain and thus contribute to the ongoing efforts to improve broiler chicken production in Jordan.

MATERIALS AND METHODS

Study area, chicks, housing, and feeding

The study was set up during the period from April 25th to May 30th 2016 and it was performed for a period of five successive weeks in a semi-controlled broiler chicken house. The location of the study area lies between Latitude of 31°27" and Longitude of 35°74", and is located in Southern Jordan (Karak District), at an altitude of 960 m. Fertile eggs were obtained from keepers and commercial broiler hatcheries, representing three broiler strains (Lohmann, Hubbard, and Ross). The eggs were kept in an incubator at 37.5°C and 60% RH. On the 18th day of incubation, all eggs were transferred from the incubator to the hatcher, which operates under conventional conditions. One-day-old chicks of the three strains were reared under an intensive farming system in the poultry house at the Animal Farm, Agricultural Research Station, Mutah University, Karak, Jordan. All procedures performed in this study involving animals followed the ethical standards of the Animal Care and Use Committee (No. AGR-82006), Mutah University, Karak, Jordan. The study was conducted using healthy chicks, and they were kept under close clinical observation throughout the experimental period by a veterinarian. Routine management was carried out, such as cleaning the pens, washing the feeders and drinkers of the chicks, and cleaning the chick feces. All the chicks were vaccinated against Newcastle and infectious Bursal diseases on the 7th and 14th days of the experimental period, respectively.

The chicks were maintained in separated pens of five replicates of each strain in a semi-open housing facility (50 x 10 x 2.5 m: length x width x height). All the chicks had free access to drinking water *ad libitum*. All the chicks were fed *ad libitum* a similar standard commercial diet of 2.8 Mkcal metabolizable energy, 16.50% CP, 3.10% calcium, and 0.35% available phosphorus for starters (1st to 14th days), as well as 3.1 Mkcal metabolizable energy, 20% CP, 3.10% calcium, and 0.35% available phosphorus for growers (15th to 35th days), formulated to meet the NRC requirements (NRC, 1994).

Experimental design and data collection

One-day-old chicks were separately allocated to three treatment groups; Lohmann, Hubbard, and Ross broiler strains. The initial number of each strain was 500, divided into five replicates of 100 chicks per replicate, with a stocking density of 12 birds/m2. The final number of each group, after counting mortality during experiment period, was (n = 443). Lohmann (n = 459), Hubbard (n = 458), and Ross (n = 443) with a stocking density of 12 birds/m2. Each treatment group had five replicates according to a completely randomized design, so that mean values differ as little as possible.

The live body weight (LBW) was measured in mass (weight) per bird per week. LBW (kg/bird) of the birds in each treatment group was weighed immediately after hatching and then at weekly intervals using a digital balance for five consecutive weeks of the experimental period. The mean BWG (kg/bird) was calculated at the end of each week and expressed as BWG = BWf - BWi; where BWf represents the body weight at the end of the week, and BWi indicates the body weight at the beginning of the week. Additionally, during rearing, the feed intake (FI; g/bird) was weekly recorded as the difference between feed supplied and the remaining feed in each feeder, and the total FI was calculated at the end of the experiment. Feed weighed at the same time birds were considered by a hanging spring balance. The FCR was calculated at the end of the investigation as the amount of feed consumed per unit of body gain (g feed/g gain). The livability rate (%) was calculated at the end of the experiment by dividing the number of live birds by the total number of birds at the beginning of the experiment. The product was then multiplied by 100 to obtain the livability rate. Throughout the duration of the experiment, the temperature was initially maintained at 33°C and gradually reduced by 2°C every week using a digital Thermo Hygrometer. The birds were reared under continuous lighting and an RH of about 60%.

Statistical analysis

The statistical analysis was done using the Proc General Linear Model (GLM) (SPSS 19.0, SPSS Inc., Chicago, IL, USA) (SPSS, 1997). Two-way Repeated Measure Analysis of Variance (ANOVA) was applied to evaluate the influence of the sampling time and the differences among the three broiler strains. If ANOVA indicated an acceptable level of significance ($p<0.05$), Bonferroni's test was performed for *post hoc* comparison (Zar, 1999). Chi-Square Test was processed to analyze differences in livability rate values between the different strains. In addition, a correlation analysis between the LBW and BWG parameters was conducted using Spearman's correlation method (Zar, 1999). All data obtained were presented as means along with their standard deviations (SD).

RESULTS

Live body weight

Time course changes in mean LBW of the three broiler chicken strains are shown in Figure 1. The results indicated that the mean weekly LBW showed a significant increase in the three broiler strains; Hubbard ($F = 185.67$; 5, 24 df; $p<0.05$), Lohmann ($F = 694.26$; 5, 24 df; $p<0.05$), and Ross ($F = 224.92$; 5, 24 df; $p<0.05$). Initial LBW was 0.14±0.01, 0.15±0.03, and 0.16±0.01 kg/bird in Hubbard, Lohmann, and Ross, respectively, with no significant differences among them. The mean LBW of the birds raised from 1 to 5 weeks of age and reached a final LBW of 1.81±0.20, 1.69±0.06, and 1.80±0.18 kg/bird in Hubbard, Lohmann, and Ross, respectively. Furthermore, the results indicated no significant differences in the mean LBW among the three broiler strains in the first two experimental weeks ($F = 0.518$-3.470; 2, 11 df. In contrast, the mean LBW in the 3rd, 4th, and 5th weeks of the experiment was significantly higher in Hubbard and Ross than in Lohmann ($F = 4.251$-5.973; 2, 11 df; $p<0.05$).

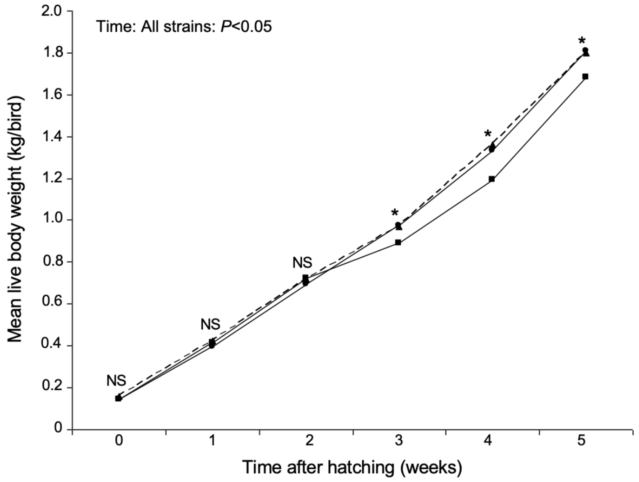

Figure 1 – Time course changes in mean live body weight (kg/bird) of three broiler chicken strains. Hubbard (n=458, ●, solid line), Lohmann (n=459, ■, solid line), and Ross (n=443, ▲, dashed line). *: Indicates significant differences among the three strains within the same experimental week at $p<0.05$ (one-factor analysis of variance). NS: Not significant.

Body weight gain

The time-course changes in mean BWG of the three broiler chicken strains are presented in Figure 2. The results indicated no significant differences in the mean BWG among the three chicken strains within each week overall the experimental period. The weekly mean BWG varied from 0.25±0.02 to 0.48±0.13 kg/bird in Hubbard, 0.17±0.09 to 0.49±0.05 kg/bird in Lohmann, and 0.25±0.02 to 0.44±0.15 kg/bird in Ross. The results indicated that at the end of the experimental period (5 weeks), the mean total BWG (kg/bird) is significantly ($p<0.05$) higher in Hubbard (1.67±0.20) and Ross (1.64±0.18) than in Lohmann (1.54±0.06).

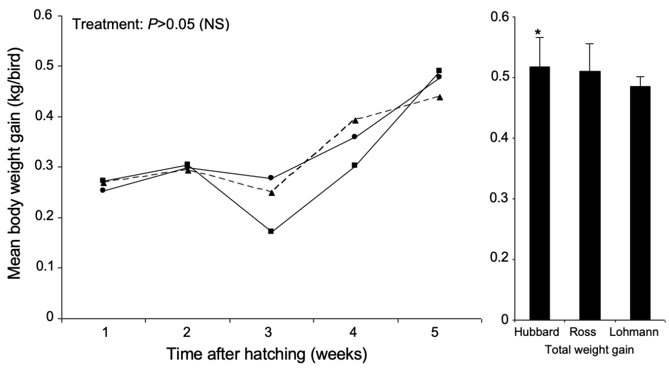

Figure 2 – Time course changes in mean body weight gain (kg/bird) of three broiler chicken strains. Hubbard (n=458, ●, solid line), Lohmann (n=459, ■, solid line), and Ross (n=443, ▲, dashed line). Bars on right side indicate mean total body weight gain during the whole experimental period.*: Indicates significant differences among the three strains at $p<0.05$ (one-factor analysis of variance). NS: Not significant.

Feed intake, feed conversion ratio and livability rate

The mean FI (g/bird), FCR (g feed/g gain), and livability rate (%) of the three broiler chicken strains are shown in Figure 3. The results showed that chicken strain had no significant effect on the total FI, and FCR. The total FI values were 3655.3±661.9, 3384.1±775.4, and 4066.3±954.1 g/bird, as well as the FCR values were 2.20±0.40, 2.21±0.53, and 2.44±0.65 g feed/g gain in Hubbard, Lohmann, and Ross, respectively. The livability rate throughout the whole experimental period (5 weeks) of the three strains did not show any significant difference among the treatment groups. Livability was numerically lower in Hubbard (92.94±4.58%) than in Ross (95.13±2.58%) and Lohmann (95.64%).

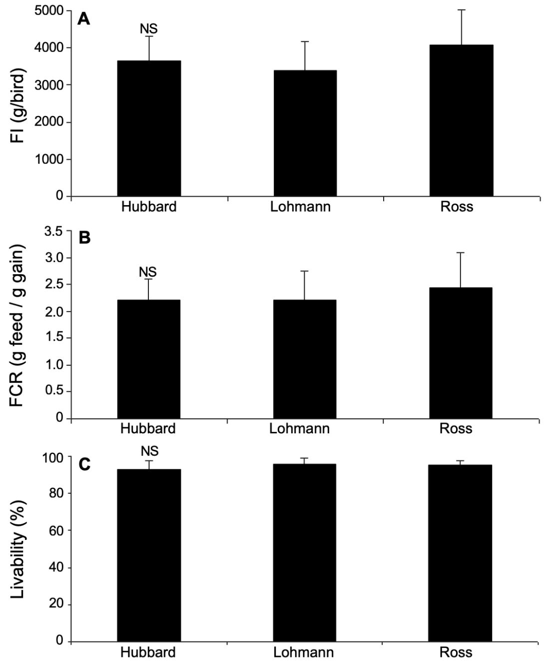

Figure 3 – Mean feed intake (A), feed conversion ratio (B) and livability rate (C) of three broiler chicken strains. Hubbard (n=458), Lohmann (n=459) and Ross (n=344). NS: Indicates no significant differences among the three different strains within each investigated parameter at $p<0.05$ (one-factor analysis of variance).

Correlation analysis

The Pearson correlation coefficient for the relationship between LBW and BWG exhibited a significant positive correlation in Hubbard (r = 0.873, $p<0.01$), Lohmann (r = 0.829, $p<0.01$) and Ross (r = 0.873, $p<0.01$).

DISCUSSION

Broiler production has developed very fast in the last decades in Jordan, and it has become one of the most crucial sectors in animal production industry (Al-Fataftah & Abdelqader, 2013; Al-Dawood & Büscher, 2014; Al-Dawood, 2016). The production factors and livability have been used as indicators of chicken welfare and the basis of genetic make-up differentiation (Al-Atiyat, 2009). High broiler weight at slaughter is the main goal of the producers (Tona *et al.*, 2004). Reduction in LBW and BWG will increase both the market age and the production costs. Identification of the appropriate strains from the standpoint of production performance and livability of broiler birds is required to promote poultry farming in the world (Biswas *et al.*, 2011; Adeniji, 2012; Kalia *et al.*, 2017).

The current results demonstrated that mean weekly LBW shows a significant increase in the three broiler strains tested. However, it should be mentioned that one of the most popular criteria for appraising the performance of broiler strains has been the growth rate (Smith & Pesti, 1998; Rezaei *et al.*, 2004). Growth curve functions are the adequate means for describing the growth pattern of LBW (Goliomytis *et al.*, 2003). Chicken growth is described as a sigmoid curve with an initial exponential development stage and a final stage of inhibited growth consisting of the gradual reduction in the growth rate following an asymptotic increase in the body weight (Aguilar *et al.*, 1983). However, the scope of the current study was only to complete the first phase of growth, which is the initial exponential development phase, because the subsequent stages are not economical for broiler producers. The current results indicated that at five weeks of age, the mean final LBW of birds was significantly higher in Hubbard (1.81 kg/bird) and Ross (1.80 kg/bird) than in Lohmann (1.69 kg/bird). Our results agreed entirely with the findings of Hossain *et al.* (2011), who stated that the final LBW at five weeks of age differs significantly between strains, and birds of Cobb-500 were the heaviest (1.43 kg) when compared to Hubbard Classic (1.38 kg) and MPK (1.32 kg) strains. Furthermore, Sarker *et al.* (2001) observed significant differences in LBW among different broiler strains at six weeks of age, in which ISA Vedette show higher LBW compared to Hybro and Arbor Acres. Mooreover, significant differences were observed in LBW of six commercial broiler hybrids available in Iran (Arbor Acres, Arian, Cobb 500, Hubbard, Lohmann, and Ross) (Rahimi *et al.*, 2006). It should be noted that genetic variation between strains, among other factors, might give rise to LBW variation between strains. Therefore, it is assumed that the higher LBW of Hubbard (1.81) and Ross (1.80) broiler strains might arise from the genetic make-up throughout the embryonic stage, which can lead to different growth potentials, and it may possibly be owing to the strain effect.

The present results indicated no significant differences in the mean weekly BWG among the three chicken strains. Our results agreed entirely with the findings of Hossain *et al.* (2011), who found that the BWG of the strains is not influenced by strain. The current results indicated that at five weeks of age, the mean total BWG (kg/bird) was significantly higher in Hubbard (1.67) and Ross (1.65) than that in Lohmann (1.54). In this regard, Azad (1996) stated that the BWG of Arbor Acres, Hubbard, Hybro, and ISA Vedette strains are 1.56, 1.62, 1.52, and 1.52 kg/bird, respectively. In contrast, Sarker *et al.* (2001) observed BWG of 1.37, 1.55, and 1.40 kg/bird in Arbor Acres, ISA Vedette and Hybro, respectively at six weeks of age. Rahimi *et al.* (2006) reported that differences in BWG could be attributed to hybrids of the six commercial broiler hybrids available in Iran (Arbor Acres, Arian, Cobb-500, Hubbard, Lohmann, and Ross). Therefore, in the current study, it is assumed that the higher BWG in Hubbard and Ross strains might arise from the genetic make-up during the embryonic stage. Furthermore, the differences of the LBW and BWG of the broiler strains may be explained by different factors, i.e., strain, genotype, sex, environmental conditions, and climatic effects (Hossain *et al.*, 2011; Husna *et al.*, 2017).

It is worth mentioning that another criterion for appraising the performance of broiler strains is FCR (Smith & Pesti, 1998; Rezaei *et al.*, 2004). The primary objective of poultry feeding is to convert feedstuff into human food (Husna *et al.*, 2017), since feed constitutes the most significant proportion of all costs of broiler chicken production (Poltowicz & Doktor, 2012). Therefore, the attainment of good production results is conditional on the efficient use of feeds. However, the current results showed that broiler strain has no significant effect on the total FI and FCR. The FCR values were 2.20, 2.21, and 2.44 g feed/g gain in Hubbard, Lohmann, and Ross, respectively. Our results agreed with Husna *et al.* (2017), who reported better FCR in Lohmann than that in Ross. Nevertheless, the lowest figure of FCR indicates that Hubbard birds are supposed to be superior and more efficient in converting feed to meat, hence presenting greater LBW and BWG than other broiler strains. In close agreement, although slightly closer to the present study, were the results obtained by Broadbent *et al.* (1981), 2.04 at 56 d of age; Xin *et al.* (1994), 2.2 at 56 d of age; Leterrier *et al.* (1998), 2.28 at 42 d of age, Goliomytis *et al.* (2003), 1.78 at 42 d of age, Al-Fataftah & Abu-Dieyeh (2007), 2.17 at 42 d of age, and Zuidhof *et al.* (2014), 2.88 at 42 d of age. However, the variation in FI and FCR may be explained by several factors, including strain, feed quality, palatability of feed, age, sex, individual body requirement, stage of production, climatic effect, mortality, and diseases (Husna *et al.*, 2017).

The present results showed that the livability rate was significantly unaffected by all the treatment groups throughout the trial period (5 weeks). It may, therefore, be deduced that broiler strain did not adversely affect bird livability. The current results are in agreement with the findings of Sarker *et al.* (2001), Rahimi *et al.* (2006), Rokonuzzaman *et al.* (2015), & Husna *et al.* (2017). They stated that broiler strain has no significant effect on the livability of the birds. The livability in a broiler flock is a crucial consideration for successful and profitable broiler production, and mortality should be at a meximum of 5% (livability 95%) (Gonzales *et al.*, 1998). Our results showed that Lohmann (95.64%) and Ross (95.13%) have a slightly higher livability rate than Hubbard (92.94%). Our results are within the range of livability rates stated by Husna *et al.* (2017), who found that livability rate was maximum in Hubbard Classic by a short margin (96.5%), followed by Cobb-500 (96%), Lohmann (95.5%), and Ross (95.3%). While Sarker *et al.* (2001) reported livability rates of 97%, 95%, and 94% for Arbor Acres, ISA Vedette, and Hybro strains, respectively. Additionally, Hossain *et al.* (2011) reported livability rates during the experimental period (5 weeks) of 94.2%, 98.1%, and 94.2% in Hubbard Classic, Cobb-500, and MPK broiler strains, respectively. It should be mentioned that in Jordan, the Newcastle disease, predators, and parasites were the leading causes of flock losses (Abdelqader *et al.*, 2007). Furthermore, infectious and metabolic disorders are common in chickens and cause mortality that results in considerable economic losses (Rath *et al.*, 2009; Al-Dawood, 2016). However, the differences in the livability of one broiler strain in comparison to the others might be due to several factors, i.e., strain, sex, feed, disease incidences, and environmental conditions (Hossain *et al.*, 2011). Moreover, it might be due to less adaptability of a strain to environmental conditions (Kalia *et al.*, 2017), and its hardiness nature and worse metabolic rate as compared to other strains (Balog *et al.*, 2000). The current results showed a significant positive correlation between LBW and BWG in the three chicken strains investigated. Our results are in agreement with the findings of Rahimi *et al.* (2006), who also reported a significant positive correlation between LBW and BWG (r=0.9).

A profound change in the productivity of the broiler chicken industry has been achieved via intentional genetic selection through traditional quantitative techniques (Hunton, 2006). Early on, limited statistical capabilities forced geneticists to focus on the most economic parameters that were easily measured and highly heritable, i.e., LBW, FI, FCR, and yield (Hunton, 2006). Improvement of FCR is achieved primarily by reducing the growing period, which has been accomplished by selection for growth rate and FCR (Marks, 1995). In this regard, in Jordan, Lohmann, Hubbard, and Ross broiler chickens were grouped based on nucleotide DNA sequencing involving a similar selection factors. Those three broiler chicken strains shared haplotypes, which were grouped in the evolutionary trees, and had a common ancestry origin (Al-Atiyat & Abudabos, 2014).

CONCLUSIONS

The present study addresses the effect of broiler strain on LBW, BWG, FI, FCR, and livability in improving the productivity of Jordanian broiler chickens. The present findings indicated that the production performance of broilers is considerably affected by their strains, whereas Hubbard achieved higher LBW and BWG, and the best FCR as compared to the other strains. It concludes that the Hubbard strain has provided comparatively better growth responses, so this strain may be recommended as economic and more suitable for rearing under the farm management in Jordan. It is hoped that the present outcomes could be used for the breeding soundness assessment to select the correct chick strain and may contributed to the ongoing efforts to improve chicken production in Jordan.

ACKNOWLEDGEMENTS

This study was supported financially by the Scientific Research Deanship at Mutah University through the research projects No.: BA. 120/14/1542. The staff of the poultry house at the Animal Farm, Agricultural Research Station, Mutah University, Karak, Jordan is greatly acknowledged.

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