IJAS Iranian Journal of Applied Animal Science

The Influences of Partially Replacement of Maize Corn by Broken Rice and Sugar Beat Pulp on Growth Performance, Carcass Traits and Economics of Meat-Type Quails

Research Article

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Received on: 6 Jan 2016
Revised on: 14 Mar 2016
Accepted on: 15 Apr 2016
Online Published on: Sep 2016

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Online version is available on: www.ijas.ir

ABSTRACT

The present study was performed to investigate the effect of partially replacing of corn by broken rice (BR) and sugar beet pulp (SBP) in the diet on growth performance and carcass traits of growing Japanese quails. A total number of 324 unsexed one week old Japanese quail chicks fed on diets replacing 0, 3, 6, 9, 12 and 15% of corn by BR and SBP mixture (1:1) to study their effect on Japanese quail performance. Results indicated that live body weight increased significantly by 4.05 and 7.63% when birds fed 9% BR and SBP at 3 and 5 weeks of age, respectively, compared to the control. Compared to the control, treatment with 9% BR and SBP improved body weight gain by 5.54, 12.31 and 9.08% during 1-3, 3-5 and 1-5 weeks of age. The best feed intake was recorded in quails fed BR and SBP at 6% substituted for corn diet, while the best feed conversion ratio was observed in quails fed BR and SBP at 15%. The relative weights of internal organs were significantly affected by the dietary treatments, but the effect on either dressing or carcass yield was not significant. The economic feasibility was higher when birds fed the highest level of BR plus SBP (15%) in the diet being 1.64 compared with the control and other treatments. In conclusion, the results of this study indicated that, taking the economic efficiency into consideration, the dietary level of 15% BR plus SBP replaced maize diet could be the best percentage till 5 weeks of age.

KEY WORDS broken rice, economics, performance, quails, sugar beet pulp.

INTRODUCTION

One of challenges which was and still facing the poultry industry in the developing countries is high prices of soybean meal and corn which mainly used in poultry diets. So, nutritionists should exert more efforts to find nutritious and affordable feedstuffs from untraditional sources. Increasing costs of poultry feeds have continued to be a major drawback in the developing countries, as the cost of feed is nearly about 65 to 70% (Nworgu *et al.* 1999) and 70 to 75% (Opara, 1999) of the total cost of production *vs.* about 50 to 60% in the developed countries as reported by Tackie and Flenscher (1995). One of the best strategies to reduce the costs of poultry feeds is using alternative, available and locally cheaper ingredients (Abd El-Hack, 2015). Several researchers have emphasized the dire need for utilizing alternative feed ingredients derived from human or industrial uses (Durunna *et al.* 1999; Fanimo *et al.* 2007; Nsa *et al.* 2007). In this respect, nutritionists used a lot of alternatives in formulating poultry diets such as distillers died grains with solubles (DDGS) (Abd El-Hack *et al.* 2015a; Abd El-Hack *et al.* 2015c; Abd El-Hack and Mahgoub, 2015), raw *Faba bean* (Abd El-Hack *et al.* 2015b), sun flower meal (Alagawany *et al.* 2015) and broken rice (Ashour *et al.* 2015). By-products of rice are extensively abundant wastes from rice industry and the amount of their production de-

pends mainly on type of rice and the milling rate (Esa *et al.* 2013). Recent studies showed the use of rice by-products as functional foods as a result of their content of phenolic compounds, vitamins, minerals and fiber which have the ability in lowering cholesterol as well as anti-atherogenic activity (Wilson *et al.* 2002). The reproductive part is known as rice germs, which germinate and grow into plants (OECD, 2004). The content of vitamin E in rice germ is about 5 times higher than that in rice bran. α-Tocopherol is the major component of vitamin E in rice germ; it is the best active form of vitamin E. Furthermore, rice germ involves a good amount of vitamins (B1, B2 and B6), fiber and neurotransmitter γ–aminobutyric acid (GABA), which is reported to have several beneficial health effects. It could help in lowering the blood pressure, enhancing cognition and lowering blood glucose levels. The level of γ–aminobutyric in rice bran is 5 times higher than the level in rice germ (Shanggong *et al.* 2007). Corn is the main cereal grain used in poultry feeds and production. The logistic costs caused an increase in corn price, particularly during off-season periods as reported by Moura *et al.* (2010). So, agro-industrial by-products such as broken rice could be a good alternative to corn due to its low price and high availability, as well as similar metabolizable energy and crude protein contents to that of corn gain (Daghir, 2008). Broken rice is consisting of broken grains derived from the process of sieving after rice hulls are removed. According to Central Laboratory for Food and Feed in Cairo, chemical composition of broken rice is: crude protein 8%, crude fiber 10.1%, ash 2% and metabolizable energy 3090 kcal\kg diet (Ashour *et al.* 2015).

Sugar beet pulp (SBP) is also one of alternatives that could be used in poultry diets. It is the solid residue which remains after sugar extraction from sugar beet roots that represents 6% of roots weight (Kjaergaard, 1984). Dried SBP is a rich by-product in carbohydrates, so it was used as a partial source of energy in the rations of growing calves, dairy cattle, lambs (Hemingway *et al.* 1986; Ayaşan *et al.* 2012) and rabbit (Volek *et al.* 2002). The majority of previous studies concluded that the nutritive value of SBP is comparable to corn or barley. The crude protein level in SBP is considered low. Abedo (2006) found that SBP content of crude protein averaged from 6.6 to 13.3% with an average value of 9.9%. Sugar beet pulp also includes high content of crude fiber which represents about 19.7% in average (Abedo, 2006). It is worthy to note that the fibrous carbohydrates of SBP are easily digested as a result of low content of its lignin and the amorphous structure of its cellulose. On the other hand, SBP is deficient in phosphorus, fat, certain β-carotene and vitamins which have been confirmed as the reason for even lower bioavailability of SBP nutrients. There are investigations on using either BR or SBP in laying Japanese quails diets (Swain *et al.* 2006; Oliveira *et al.* 2007), but little literature are available on the use of these feedstuffs for growing quails (Ashour *et al.* 2015). Therefore, this study aimed to evaluate the effects of the inclusion of BR and SBP together in the same diet as a substitute for corn in growing Japanese quails diets on growth performance, carcass yield and economics of production.

MATERIALS AND METHODS

Experimental design and husbandry

The present study was carried out at Poultry Research Farm, Poultry Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. All procedures of the experiment were carried out according to the Local Experimental Animal Care Committee and approved by the ethics of the institutional committee of Poultry Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

A total number of 324 unsexed one week old Japanese quails with average initial body weight of (24.14±0.54) were randomly assigned in a complete randomized design into 6 treatment groups, (54 chicks in each group). Each group of birds was subdivided into three replicates, each of 18 chicks. Each replicate was housed in a cage (90×40×40 cm^3). Six experimental diets were formulated according to NRC (1994) to have a basal diet and five diets with graded levels of BR and SBP mixture (1:1) (3, 6, 9, 12 and 15%) as a substitution for yellow corn (Table 1).

Chicks were grown in brooders with raised wire floors and were reared under the same managerial and hygienic conditions. The lighting pattern was 23 hours light: 1 hour dark. Feed and water were *ad libitum* throughout the whole experimental period (1-5 weeks of age). All chicks received feeds from placement until 35 days of age in mash form, according to its treatment.

Collection of the data

Growth performance

Chicks were weekly weighed individually at intervals. Mortality was daily recorded. Average daily feed intake (ADFI), body weight gain (BWG) and feed to gain ratio (FCR) were calculated from these data by period and cumulatively. Feed wastage was daily recorded and the data were used to estimate the feed consumption. Protein efficiency ratio (PER) was calculated from body weight gain divided by protein intake (Kamran *et al.* 2008).

Carcass characteristics

At the termination of the experiment, 30 birds (five each group) were sampled randomly for carcass evaluations at 5 weeks of age, weighed and manually slaughtered. The car-

casses were weighed and the weights of the liver, gizzard and heart were recorded and expressed as g/kg of slaughter weight (SW). Carcass and dressed weights studied (dressed weight=carcass weight plus giblets weight) / live body weight.

Economic efficiency

Economic efficiency of the product (growth rate) was calculated from the input and output analysis based upon the differences in growth rate and feeding cost (Heady and Jensen, 1954).

Statistical analysis

Data was subjected to ANOVA procedure using a completely randomized design using the GLM procedures of SAS (SAS, 2001). The differences among means were determined using the post-hoc Tukey's test. Statements of statistical significance are based on ($P<0.05$) unless otherwise stated.

RESULTS AND DISCUSSION

Growth performance

Results in Table (2) show live body weight and body weight gain of growing Japanese quails fed the different levels of BR and SBP replaced maize from 1 to 5 weeks of age. The results indicated that LBW and BWG were significantly ($P<0.05$ or $P<0.01$) affected during all the different experimental periods.

The level of 9% BR plus SBP recorded the best values of LBW and BWG within all experimental periods studied compared with the control diet and other treatment groups. Live body weight increased by 4.05 and 7.63% when birds fed 9% BR plus SBP at 3 and 5 weeks of age, respectively compared to the control. For BWG, the treatment with 9% BR plus SBP improved BWG by 5.54, 12.31 and 9.08% during 1-3, 3-5 and 1-5 weeks of the age comparing with the control group. Our results are in line with those obtained by Medugu *et al.* (2010) and Ashour *et al.* (2015) who found that the use of rice is a potential energy source and feeding trials using broken rice in poultry diets have produced good results.

Furthermore, Swain and Barbuddhe (2008) pointed out that broken rice (rice kani) can replace maize in diets of Japanese quail chicks up to a level of 20% in the diet without any adverse impact on their performance with appreciable reduction in the cost of feed. Sethi *et al.* (2006) demonstrated that broken rice could replace up to 50% of dietary maize corn with no bad effects on quails growth performance. Nanto *et al.* (2012) observed that the final weight of broilers was higher when dehulled paddy rice was totally replaced corn in the diets.

Also, Gonzalez-Alvarado *et al.* (2007) found that broilers fed a diet containing dehulled paddy rice as main energy source yielded better performance in compare with those fed corn and belonged this impact to the lower fiber and higher starch contents in rice. Similarly, Tester *et al.* (2006) reported that the good performance of birds fed diets containing dehulled rice can be attributed to lower amylase and non-starch polysaccharide contents, in addition to its smaller particle size. Contrarily, Edwin *et al.* (2002) reported no significant differences in body weight of broilers at eight weeks of age when fed diets in which broken rice replaced maize corn. For SBP effect, Pettersson and Razdan (1993) found that chickens fed diets contained 23 g of SBP/kg diet gave higher live body weights compared with the control group. On the other hand, Alagawany and Attia (2015) found no significant effect of SPB inclusion on live body weight and body weight change of laying Japanese quails. Feed intake (FI) was significantly ($P<0.05$ or $P<0.01$) affected by BR plus SBP replacement during all experimental periods. While, FCR was significantly ($P<0.05$) affected during the period of 1-5 weeks of age only as shown in Table 3. The best FI was recorded in quails fed BR and SBP at 6% substituted for corn diet. With regard to feed conversion, quails fed BR and SBP at 15% produced the best. Improving feed intake and increasing LBW and BWG are the reasons for improved FCR in quails fed 15% BR and SBP. Our findings are in harmony with those reported by Vicente *et al.* (2008) who stated that broken rice is one of feedstuffs that relatively stimulate high glucose and insulin postprandial responses, so it could increase feed intake and weight gain. On the other hand, Edwin *et al.* (2002) found that feed intake and feed efficiency did not show any significant differences among treatments included different levels of broken rice. Also, Almirall *et al.* (1997) who stated that increasing SBP inclusion in the diet from 0 to 75 and 150 g kg^{-1} feed from 22 to 55 weeks of age had no effect on overall feed consumption of Hi-sex laying hens. Gonzalez-Alvarado *et al.* (2010) found that the inclusion of 3% SBP in the diet declined feed intake from 25 to 42 days of age as compared to the control group. Furthermore, Filgueira *et al.* (2014) found that increasing levels of broken rice (0, 20, 40, 60, 80 and 100%) in replacement of corn did not affect feed intake, weight gain or feed conversion ratio ($P>0.05$). Brum *et al.* (2007) did not find any significant effects ($P>0.05$) on feed intake, weight gain, or feed conversion ratio by broken rice in broiler diets at the levels of 0, 20 and 40%. Ashour *et al.* (2015) found that feed intake was significantly ($P<0.05$ or $P<0.01$) affected by broken rice replacement during the different experimental periods, also FCR was statistically ($P<0.05$) impacted by broken rice levels during the period of 1-5 weeks of age only.

Table 1 Composition and calculated analysis of the experimental diets

Ingredients	Broken rice plus sugar beet pulp substitution rate (%)					
	0	3	6	9	12	15
Corn	60.00	58.20	56.40	54.60	52.80	51.00
Broken rice	-	0.90	1.80	2.70	3.60	4.50
Sugar beet pulp	-	0.90	1.80	2.70	3.60	4.50
Soybean meal (44%)	27.80	28.00	27.50	26.80	25.00	24.00
Corn gluten meal (60%)	2.00	1.90	2.00	2.40	3.80	4.40
Limestone	0.20	0.20	0.20	0.20	0.20	0.20
Protein concentrate (48%)[1]	10.00	10.00	10.00	10.00	10.00	10.00
Plant oil	-	0.10	0.50	0.80	1.20	1.60
Calculated analysis[2]						
CP %	23.50	23.50	23.40	23.40	23.30	23.30
Metabolizable energy (ME) kcal/kg	2960	2942	2941	2940	2948	2947
Ca %	0.80	0.80	0.80	0.80	0.80	0.80
Available P %	0.35	0.35	0.35	0.35	0.35	0.35
Lysine %	1.20	1.20	1.20	1.20	1.20	1.20
Met + Cys %	0.90	0.90	0.90	0.90	0.90	0.90
Determined analysis[3]						
Crude protein (%)	23.45	23.76	23.85	23.89	23.65	23.76
Crude fat (%)	2.15	2.17	2.02	2.07	2.15	2.17
Ash (%)	5.24	5.90	5.45	5.73	5.45	5.32
Price/ton/diet, L.E.[4]	3700	3200	2700	2460	2230	2150

[1] Protein concentrate (48%) contains: crude protein: 48%; ME: 2533 kcal/kg deit; Calcium: 6.2%; Available phosphorus: 2.9%; Lysine: 2.3% and Methionine + cystine: 2.4%.
[2] Calculated analysis according to NRC (1994).
[3] According to AOAC (2003).
[4] Caculated according to the price of feed ingredients when the experiment was started.

Table 2 Effects of treatment on live body weight and body weight gain of growing Japanese quail

Parameters	Broken rice plus sugar beet pulp substitution rate (%)						
	0%	3	6	9	12	15	SEM
Live body weight (g)[2]							
1 week	29.84	29.84	29.68	29.84	29.68	29.84	0.09
3 weeks	103.90^{c}	106.40^{a}	102.50^{bc}	108.28^{a}	105.78^{b}	104.8^{b}	0.33
5 weeks	175.78^{c}	179.06^{b}	182.03^{b}	190.31^{a}	177.50^{c}	179.06^{b}	1.24
Body weight gain (g)[2]							
1-3 weeks	5.29^{b}	5.46^{a}	5.20^{b}	5.60^{a}	5.42^{ab}	5.35^{ab}	0.02
3-5 weeks	5.13^{c}	5.19^{c}	5.68^{a}	5.85^{a}	5.12^{c}	5.30^{b}	0.09
Overall (1-5 weeks)	5.21^{c}	5.32^{b}	5.44^{a}	5.73^{a}	5.27^{b}	5.32^{b}	0.06

The means within the same row with at least one common letter, do not have significant difference (P>0.01).
SEM: standard error of the means.

Table 3 Effects of treatment on daily feed consumption and feed conversion ratio of growing Japanese quails

Parameters	Broken rice plus sugar beet pulp substitution rate (%)						
	0	3	6	9	12	15	SEM[1]
Daily feed consumption (g)[2]							
1-3 week	12.29^{bc}	12.29^{bc}	13.37^{a}	12.93^{b}	12.09^{c}	11.92^{c}	0.10
3-5 weeks	23.59^{b}	25.20^{a}	26.15^{a}	25.51^{a}	22.55^{c}	22.39^{c}	0.28
Overall (1-5 weeks)	17.94^{bc}	18.74^{b}	19.91^{a}	19.22^{a}	17.22^{c}	17.16^{c}	0.32
Feed conversion ratio (feed g/gain g)							
1-3 weeks	2.32	2.24	2.57	2.30	2.23	2.22	0.02
3-5 weeks	4.59	4.85	4.60	4.35	4.40	4.22	0.04
Overall (1-5 weeks)	3.44^{ab}	3.51^{a}	3.65^{a}	3.35^{bc}	3.28^{c}	3.22^{c}	0.01

The means within the same row with at least one common letter, do not have significant difference (P>0.01).
SEM: standard error of the means.

Authors added that the best FI was obtained in quails fed broken rice at level of 50% replaced corn maize diet, whereas quails fed broken rice at level of 30% replaced by corn maize diet had the best FCR compared to other treatments. Data in Table 4 illustrate the effect of treatments on PER for growing Japanese quails. The inclusion of BR and SBP significantly (P<0.01) impacted PER only at the first period (1-3 weeks of age).

Table 4 Effects of treatment on protein efficiency of growing Japanese quails

Items	Broken rice plus sugar beet pulp substitution rate (%)						
	0	3	6	9	12	15	SEM
1-3 weeks	1.83[c]	1.89[b]	1.66[d]	1.84[c]	1.92[a]	1.91[a]	0.02
3-5 weeks	0.93	0.88	0.92	0.98	1.26	1.01	0.05
Overall (1-5 weeks)	1.24	1.21	1.17	1.27	1.49	1.32	0.04

The means within the same row with at least one common letter, do not have significant difference (P>0.01).
SEM: standard error of the means.

The level of 12 % recorded the highest value (1.92) of PER followed by the level of 15% (1.91) compared by the control group and the other treatments.

The improvement in FCR, BWG and protein efficiency ratio found in groups fed of 9, 12 and 15% of BR and SBP replaced maize diet in the entire period 1-5 weeks of age could be due to the existence of phenolic base compounds in rice by products and SBP, in addition to having good amounts of minerals, vitamins and fiber that can help to lower cholesterol and enact anti-atheogenic activity (Wilson *et al.* 2002; Alagawany and Attia, 2015; Ashour *et al.* 2015).

Moreover, Shanggong *et al.* (2007) theorized that rice germ has a substantial concentration of vitamins such as B_1, B_2 and B_6, fiber and neurotransmitter γ–aminobutyric acid (GABA), which is suggested to have several beneficial health effects which reflect finally in improving FCR and BWG. In addition, Swain and Barbuddhe (2008) reported that broken rice is free of aflatoxins that pose threat to the survivability of livestock's and poultry.

Vicente *et al.* (2008) demonstrated that feedstuffs that stimulate relatively high insulin and glucose postprandial responses, such as BR and SBP, could improve feed intake and weight gain by animals fed diets containing increasing levels of these feedstuffs. These results are in agreement with those reported by Swain and Barbuddhe (2008) who found that broken rice can replace maize up to a level of 20% in Japanese quails diets without any adverse effect on their performance. Furthermore, Medugu *et al.* (2010) and Nanto *et al.* (2012) postulated that using rice by-products as potential energy source in poultry diets have produced good results.

On the other hand, Brum *et al.* (2007) did not find any significant impact (P>0.05) on FI, BWG or FCR when evaluating the replacement of corn by broken rice in broiler diets at the levels of 0%, 20% and 40%. Moreover, Cancherini *et al.* (2008) also observed no significant effect of 22.5% dietary inclusion of broken rice on broiler growth performance.

Carcass characteristics

Results in Table (5) showed the carcass characteristics involving dressing, carcass, giblets, heart, liver and gizzard yield percentages.

The evaluation of carcass traits showed that the inclusion of BR and SBP in the diets did not significantly affect dressing and carcass yield percentages of meat-type quails compared to the control group. Heart, liver, gizzard and giblets yield percentages were significantly (P<0.05 or P<0.01) impacted by BR and SBP percentage replaced maize diet compared to control group. Albeit insignificant, the best dressing and carcass yield values were produced by growing quail chicks fed BR and SBP at 9% in the diets. Similar results were obtained by Sethi *et al.* (2006) who reported that growth performance was not influenced by replacing 50% of dietary corn by broken rice. Since, carcass and gizzard pigmentation linearly depressed with increasing levels of broken rice in broiler diets because of the lower content of carotenoids of this feedstuff (Brum *et al.* 2007). Our obtained results are in accordance with those of Filgueira *et al.* (2014) and Ashour *et al.* (2015) who assured that the substitution of broken rice for maize corn in the diets did not significantly affect dressing percentage, breast and leg yields of meat-type quails. The results of carcass yield are in line with those found in broilers by Brum *et al.* (2007) and Cancherini *et al.* (2008) who found no effect of corn replacement by broken rice at levels of 0, 20 or 40% in the diet on broiler carcass or cuts yields. In a partially agreement with our results, Nanto *et al.* (2012) observed that increasing the substitution level of corn by broken rice and dehulled paddy rice reduced gizzard weight. Authors attributed this effect to the declined activation of this organ as a result of the higher content of starch and lower non-starch polysaccharide in broken rice as previously reported by Choct (2002). In this context, Alabi *et al.* (2014) suggested that increasing the size of gizzard could occur due to the need for more grinding activities resulting from increased fiber content of the diet. This may explain the reasonable result of the weight of the gizzard in the present study, although the weight did not increase linearly, the existence of SPB played a good role in maintain the shortage of fibers which resulted from BR inclusion.

Economics

The economic feasibility evaluation is presented in Table 6. Data showed that the feed cost per kilogram of live weight gain was gradually depressed as the inclusion level of BR and SBP increased.

Table 5 Effects of treatment on carcass yield of growing Japanese quails at 5 weeks of age

Parameters	Broken rice plus sugar beet pulp substitution rate (%)						
	0	3	6	9	12	15	SEM
Carcass yield, %	75.80	76.60	76.40	79.00	76.00	76.10	0.90
Heart, %	1.02^{a}	1.10^{a}	1.00^{a}	0.90^{b}	1.00^{a}	0.90^{b}	0.04
Liver, %	3.50^{a}	3.10^{b}	2.90^{b}	2.50^{bc}	2.10^{c}	2.10^{c}	0.24
Gizzard, %	2.30^{ab}	2.40^{a}	2.20^{bc}	2.20^{bc}	2.10^{c}	2. 60^{a}	0.10
Giblets, %	6.90^{a}	6.70^{a}	6.20^{b}	5.70^{bc}	5.30^{c}	5.70b^{c}	0.34
Dressing, %	82.80	83.40	82.70	84.40	81.40	81.90	0.86

The means within the same row with at least one common letter, do not have significant difference (P>0.01).
SEM: standard error of the means.

Table 6 Effects of treatment on the economics of growing Japanese quails

Items	Broken rice plus sugar beet pulp substitution rate (%)					
	0	3	6	9	12	15
Price/kg feed (LE)	3.70	3.20	2.70	2.46	2.23	2.15
Price/kg meat (LE)	20.00	20.00	20.00	20.00	20.00	20.00
Feed conversion ratio	3.78	3.86	4.02	3.69	3.61	3.54
Price of feed to produce one kg meat (LE)	14.00	12.36	10.84	9.07	8.05	7.62
Net revenue* (LE)	6.00	7.64	9.16	10.93	11.95	12.38
Economic efficiency (EE)	0.44	0.63	0.85	1.22	1.50	1.64

*Net revenue= price/kg meat - price of feed to produce one kg meat.
LE: Egyptian pound.

Net revenue and economic efficiency were gradually increased as the inclusion level of BR and SBP increased in replacement of corn in quails diets. It is clear that the economic feasibility was higher when birds fed the highest level of BR and SBP (15%) in the diet being 1.64 compared with the control and other treatments. Our findings are in agreement with those reported by Rao *et al*. (2000) who reported that BR could be completely used instead of corn in the diets of broiler breeder to reduce the costs of production at prices prevailing in that situation. Swain *et al.* (2006) pointed out that the cost of feed was reduced when 30% of corn was replaced by broken rice.

CONCLUSION

Based on the present findings, BR and SBP can be considered a potential substitute of corn in growing Japanese quail together in the same diet up to 15%. Since it is a by-product of rice processing or sugar beet pulp which composition may vary, studies for determination of metabolizable energy and digestible amino acid contents may allow maximizing its inclusion in quail diets.

ACKNOWLEDGEMENT

The authors acknowledge the Department of Poultry, Faculty of Agriculture, Zagazig University, (Egypt) for their cooperation.

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