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EPIGENETICS AFFECTING EGG PRODUCTION TRAITS THROUGH THE ADDITION OF TURMERIC IN DIETS AND ESTIMATING GENETIC PARAMETERS IN THREE INBRED SYRIAN QUAIL GENOTYPES F4

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Abstract

The study was conducted at the Aleppo University Research Centre. It evaluated the effects of a genetic improvement programme of inbreeding and epigenetics by adding different levels of turmeric powder in diets on production traits. It also used epigenetic and phenotypic information to reduce the negative effects of fourth-generation female inbred Syrian quail genotypes, estimate production/genetic parameters on egg production/quality traits, and establish phenotypic and genetic correlations between parent-offsprings through variance components in the generations. Data analysis of the fourth generation indicated that the second group 1% turmeric recorded the highest value for most of the egg production coefficients. Heritability coefficient values for the studied traits ranged from 0.22 to 0.68 while phenotypic correlations for EN and EM traits were positive 0.88. Strong genetic correlations were observed between ShW and YW, and EM and YW, respectively. Multigenerational genetic improvement programmes using inbreeding to create pure breeds and epigenetics using turmeric to reduce the negative effects of inbreeding and improve production parameters for local Syrian quail.

Keywords: Epigenetics, Syrian quail, Inbreeding, Turmeric, Egg production, Genetic parameters.

تأثير علوم تفعيل الجينات في صفات إنتاج البيض بإضافة الكركم في العليقة وتقدير المؤشرات الوراثية في ثلاثة أنماط وراثية مرباه داخليا من طائر السمان السوري F4

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الخلاصة

أجريت الدراسة في مركز بحوث جامعة حلب لتقييم تأثير برنامج التحسين الوراثي بالتربية الداخلية والوراثة اللاجينية بإضافة مستويات مختلفة من مسحوق الكركم (0–1 أو 2٪) في الوجبات الغذائية على صفات انتاجية واستخدام المعلومات الوراثية والمظهرية للحد من الآثار السلبية للتربية الداخلية في ثلاثة أنماط وراثية للسمان السوري الفطري (297 أنثى) الجيل الرابع F4 وتقدير المعلمات الإنتاجية/ الوراثية لدراسة صفات إنتاج البيض وجودة البيض خلال شهرين من ذروة إنتاج البيض في عمر 6–7 أشهر، وتقدير كتلة البيض (EM) وعدد البيض (EW)، وزن البيض (EN)، ووزن القشرة (SW)، ومؤشر الشكل (SI)، وحدات هوف (HU)، مؤشر الزلال (AI)، مؤشر الصفار (YI) وقابلية التوريث h2 والارتباطات المظهرية rp والارتباط الوراثي rg من الارتباط بين الآباء والنسل من خلال مكونات التباين في الجيل. أشار تحليل البيانات للجيل الرابع إلى أن المجموعة الثانية 1% من الكركم سجلت أعلى قيمة لمعظم معاملات إنتاج البيض. تراوحت قيم معامل التوريث للصفات المدروسة من 0.22 إلى 0.68. كانت الارتباطات المظهرية لسمات EN وEM موجبة 0.88. ولوحظت ارتباطات وراثية قوية (0.68، 0.58) بين SW وYW؛ EM وYW، على التوالي.

برامج التحسين الوراثي متعدد الأجيال باستخدام التربية الداخلية لتكوين سلالات نقية والوراثة اللاجينية بإضافة الكركم للحد من تأثير السلبي للتربية الداخلية ولتحسين المؤشرات الإنتاجية هي برامج مهمة في التقييم وفعالة لطيور السمان المحلي السوري.

كلمات مفتاحية: علم الوراثة اللاجيني، السمان المحلي، التربية الداخلية، الكركم، إنتاج البيض، المؤشرات الوراثية.

Introduction

Quail birds are important in scientific research due mainly to weight gain, high production, and low cost of care compared to other poultry (19). Inbreeding increases the percentage of genetic homozygosity at the expense of genetic diversity (10). Inbreeding also exposes genetic isolations that cause diseases and mortality in flocks, reduces productivity and vitality indicators, and increases genetic similarity to obtain pure breeds. In a study on third generation quail, domestic breeding caused a decrease in reproduction due to sibling mating (26). The comparison between microsatellite molecular markers and pedigree analysis gave more accurate results on Japanese quail for 17 generations using internal breeding, which also caused a reduction in productivity and vitality indicators (12). However, modern breeding methods such as multi-trait selection can help mitigate these effects and improve genetic parameters (15). A study on Syrian local quail F3 showed that feed additives improved egg indices (3). The addition of turmeric powder at 1-0.5% of feed showed improved meat parameters and the best feed conversion factor of 7.64 g feed to produce 1 g live weightt (4). A study showed that adding turmeric in quail feed reduced cholesterol and triglyceride concentrations in the blood and improved egg parameters 26-21. When developing and implementing breeding and genetic improvement programmes, the effect of genetic and epigenetic methods should include environmental conditions and their changes (23). Differences in the epigenetic effect are due to differences in the environmental conditions of the experiments during the developmental stages of the bird, and these differences have been shown to be inherited through successive generations (11). Many scientific researches and experiments have studied epigenetic effects in poultry, Epigenetics improved production and disease resistance in poultry (16). However, the specific effects of these modifications as feed additives in improving production parameters for generations of chickens and quail improved by internal breeding are not well-documented. While some studies have found no significant trans generational epigenetic effects on egg quality traits in meat-type quail (18), others have highlighted the potential of epigenetic factors in livestock breeding, including the use of diet additives to induce these modifications (28). The rearing system influenced gene expression in chickens, with free-range systems leading to better welfare and product quality (27). Some research is needed to explore specific effects of epigenetic feed additives on production in poultry. Egg production traits in Japanese quail are known to have low-to-moderate heritability, with potential for improvement through crossbreeding and family selection methods (5). In meat-type quails, heritability estimates for egg production have been found to be relatively low, with the highest genetic correlation observed with the second and third partial periods of egg production (20). Lastly, genetic studies of quality parameters in quail birds have been identified, with strong genetic correlations between certain traits, suggesting potential for improvement through selection (22). The finding by (24) revealed no significant effect of immune levels and arginine concentration on egg production but a significant difference in egg mass among different arginine levels, along with estimates of low-high heritability, genotypic/ph. Corr. between traits (14). It was reported that development of quail strains to meet production needs highlight the effectiveness of multi-stage selection in improving body weight and egg production despite negative trait correlation, and emphasizing the advantages of Japanese quail farming in the commercial poultry sector (6). Moreover, found no significant effect of immune levels and arginine concentration on egg production but a significant difference in egg mass among different arginine levels, along with different estimates of heritability estimates and genetic/phenotypic correlations between traits. The highest value of egg number heritability were recorded in Inbred Syrian quail birds 0.71 while genetic correlations of some egg quality traits were positive and others negative (2). A total of 26.85 eggs and 320.05 g/bird for egg number and egg mass traits were noted respectively in Syrian quail populations (1).

The importance of the quail as a source of animal protein at low cost led to the development of Syrian quail breeds for six generations starting with populations and using a genetic improvement program by inbreeding to purify breeds specialized in egg production. They were then hybridized to obtain hybrids with high quantitative production traits desired by consumers. However, the negative effects of inbreeding on production led to the application of epigenetics to mitigate those effects by adding different levels (0, 1, 2%) of turmeric (Curcuma longa) powder in diets in three fourth-generation (F4) inbred Syrian quail genotypes (black (Bl), striped (St), and creamy (Cr)).

Materials and Methods

The study experiment was conducted at the Research Farm of the Animal Breeding Unit, Animal Production Dept., Agricultural Engineering Faculty, Aleppo University from March 2022 to March 2023.

Three groups of fourth-generation (F4) inbred Syrian local quail were used with each group consisting of three genotypes [black (Bl), striped (St), and cream (Cr)], which were genetically improved for several generations starting from the populations to F4 using the inbreeding method to produce a genetically pure breed of each color. Although inbreeding causes a decrease in production parameters, it increases genetic similarity to obtain a genetically pure breed for each genotype.

Groups of inbred Syrian local quail were reared and cared for in an open barn on deep sawdust bedding in the peak egg production period at age 6-7 months under suitable hygienic conditions. Balanced feed mixtures for laying quail with 21% protein and 2900 kcal/kg and water were offered to the study birds and provided with proper ventilation and lighting for 16 hours per day and a minimum temperature of 21°C.

The quantitative production traits were studied with only the turmeric amounts varied in the feed (0, 1, 2%) while fixing other variables such as feed mixture, water, light, ventilation, age and care to ensure that only the turmeric’s role is evaluated in the production parameters. This was to estimate the impact of epigenetics in reducing the negative effects of the inbreeding system on quantitative productive characteristics, that can contribute to the development and flexibility of phenotypes in poultry. This is because it does not change the DNA sequence but increases gene expression and thus phenotypes expression can be transferred to offspring, affecting the early life programming of birds through parental nutrition which affects behaviour and productivity.

Experiment design: The research experiment was planned using a completely randomized design (CRD) for inbred Syrian local quail groups. Altogether, 297 females were allocated in a completely randomized design and divided into three treatments with different concentrations (0, 1, 2%) of turmeric powder added to the feed. Each treatment included three replicates, i.e., 3-colored genotypes, with each replicate containing 33 birds. The objective was to study egg production and quality parameters during a two-month peak production period at 6-7 months of age.

- Group 1. Control: Inbred F4 Syrian quails without added turmeric [black (Bl), striped (St), and Creamy (Cr)]
- Group 2. Inbred F4 Syrian quails with the addition of 1% turmeric [black (Bl), striped (St), and Creamy (Cr)]
- Group 3. Inbred F4 Syrian quails with the addition of 2% turmeric [black (Bl), striped (St), and Creamy (Cr)].

Studied Traits:

1. Egg production: Eggs produced were collected daily for approximately two months at age of 6-7 months during the peak production period. EN and EW(g) were recorded and EM calculated individually for each group in three Syrian quail genotypes F4, and the following factors were studied:

- EN: The average number of eggs was calculated during two months of the peak production period.
- EW: Use balance to weigh each egg individually (g)
- EM = average EN × average EW (g).

2. Internal egg quality: In peak production period, the EW, AW, ED, heights and diameters of albumin and yolk were measured to calculate shape, yolk and albumin indexes.

The yolk and the shell (g) were weighed, and then the weight of the white and the Huff units were calculated using the following equations:

- Albumen Weight (g) = EW - (YW+ ShW)
- Shape index (SI) % = [egg Length Width (mm)/egg Total Length (mm)] × 100
- Yolk Index (YI) % = [Y H (mm)/Y width (mm)] ×100
- Albumen Index (AI) % = [Average AH (mm)/Average A width (mm)] ×100
- Huff Units = 100 log [AH (mm) + 7.57- 1.7 × EW (g) 0.37].

Genetic parameters studied:

1. Heritability Coefficient (h2): The heritability coefficient was estimated from the relationship between parent and offspring, specifically from the components of maternal variance, according to the following equation:

   h2= ∂2A/∂2P = 2 bAP

   Where: h2: heritability coefficient of the trait, bAP: coefficient of regression of the educational value of the trait on its phenotypic value, ∂2A: population genetic variance, ∂2P phenotypic variance (total).

2. Genetic Correlation (rg): The genetic correlation coefficient was calculated between pairs of some egg quality traits of the fourth generation of the studied Syrian quail groups from the relationship between parents and offspring, according to the following equation:

   rg = (cov z1x2 + cov z2x1) / 2√(covz1x1) (covz2x2)

   Where: rg: genetic correlation coefficient, cov: covariance of two studied traits, z: data taken on the offspring, x: data taken on the mother, 1: the first studied trait, 2: the second studied trait.

3. Phenotypic Correlation: (rp): The phenotypic correlation of some studied traits was estimated from the relationship between parents and offspring through the following equation:
   $rPxy = Cov\ xy / (\partial x * \partial y)$
   Since: rPxy = correlation coefficient between two rows (x and y), Cov xy = the variance of two characteristics, ∂x = standard - deviation of first characteristic, ∂y= of second characteristic.

Statistical Analysis: Data were collected in Completely Randomized Design (CRD) and analyzed using SPSS Statistics 26. The means, SD, and C.V were calculated for the studied characteristics. Production and quality data, such as egg weight, number and mass of eggs, shape index, diameters of the yolk and albumin, heights of the albumin and yolk, and AW, yolk and shell of studied individuals of Syrian quail, were analyzed using the Proc GLM. (Model 1):

$X_{ij} = \mu + G_i + e_{ij}$

X_{ij} = studied trait, μ = average, G_i = genotype effect (color), e_{ij} = experimental error (residual).

The Proc corr. procedure was used to analyze phenotypic corr. of some traits of the Syrian quail.

The various covariances (COVARIANCES) were also calculated to estimate the common variances between the studied trait pairs in order to extract the values of the genetic correlation coefficients between them.

The procedure Proc reg. (from Dam components of variance) was used to estimate the values of heritability coefficients within each studied colour through the following model (Model 2):

$X_{ij} = a + b(X_i) + R_{ij}$

X_{ij} = the studied trait for sons, a = Intercept = constant, b = regression coefficient of sons on fathers, X_i = the studied trait for fathers, R_{ij} = residual.

Deviations were analyzed using Duncan's analysis.

Results and Discussion

Egg production parameters: Estimates of productivity parameters were done in the three groups of inbred Syrian quail genotypes (F4, black, striped, and cream) under epigenetics affected by adding turmeric powder in diets during period of peak egg production of two months 6-7 months old.

Table 1: Epigenetic effects of adding turmeric powder on egg production parameters of three groups of fourth-generation inbred Syrian quail genotypes (Mean± SD, C.V %).

Parameter / Genotype	Treatments						Sig. (P)
	Control 0%		Turmeric 1%		Turmeric 2%		
	X±Sd	C.V%	X±Sd	C.V%	X±Sd	C.V%	
Black quail							
EW (g)	11.84 ± 0.67	5.56	13.25±0.71	5.35	12.04±0.77	6.39	*
EN 6-7 (n)	47.90 ± 3.89	8.12	49.88 ± 3.31	6.63	48.13 ± 3.77	7.83	*
EM g/ bird	567.13± 38.97	6.87	660.91±37.99	5.74	579.48±40.08	6.91	**
Striped quail							
EW (g)	11.92 ± 0.54	4.53	12.22 ± 0.68	5.56	12.18 ± 0.62	5.09	*
EN 6-7 (n)	46.33 ± 3.95	8.52	46.87 ± 3.91	8.34	44.84± 3.76	8.38	*
EM g/ bird	552.25± 41.17	7.45	572.75±42.56	7.43	540.79±40.72	7.52	**
Creamy quail							
EW (g)	11.51 ± 0.71	6.16	13.11 ± 0.96	7.32	12.76 ± 0.87	6.81	*
EN 6-7 (n)	43.07 ± 4.67	10.84	49.04 ± 3.57	7.27	47.97 ± 3.14	6.54	**
EM g/ bird	495.73±39.26	7.91	642.91±36.84	5.73	495.73±39.26	7.91	**

EW: Egg Weight (g), EN $^{6-7}$: Egg Number 6-7 months (n), EM: Egg Mass g/bird.

The table shows the positive effect of adding turmeric powder in the feed at different concentrations on the production parameters as an epigenetic effect that reduced the negative impact of inbreeding, which is consistent with hypothesis of this studied research. The results clearly show the positive effect (p<0.05) (Table 1) of epigenetics in reducing the negative effects of inbreeding in the genotypes, the F4, and of production parameters (EW, EN, EM) during the peak egg production period. The second group (1% turmeric) reported the highest value for most egg production parameters.

Egg mass (EM): trait produced, which expresses the bird's weight production (g/bird) reported highly significant differences (p<0.01) compared to group without turmeric, with the high values in 1% turmeric group reported in three genotypes of 660.91±37.99, 572.75±42.56, and 642.91±36.84 g/bird/two month, respectively. While in another study (10) the group with 3% turmeric recorded the highest significant differences in egg mass. EM estimates in this study were 567.13±38.97, 552.25±41.17, and 495.73±39.26 egg/two months for inbred Syrian quail (Bl, St, Cr). A similar report was made by (1) with averages of egg weight at 256.25±165.24, 320.05±147.75, and 233.04±163.71 g/bird/month. Adding turmeric powder improves egg production parameters (egg mass) and supports the poultry industry.

The results of current study differ from previous researches, perhaps due to the genotypes of studied quail groups, the different concentrations of turmeric with feed, the experiment period during egg production and studied birds' ages.

Egg weight (EW): estimates in this study were 11.84 ±0.67, 11.92 ± 0.54, and 11.51 ± 0.71 g for the quail. (1) reported similar averages of egg weight (11.93± 0.44, 11.92± 0.34, and 11.34± 0.31g) while (21) recorded the highest significant differences in egg weight in the group with 54 mg/quail/day turmeric. (25) reported positive effects of adding turmeric to Japanese quail feed at 0.5-2.0% for both EW and EM.

It is noted that the second group (1% turmeric) for the EW trait recorded higher values for the three genotypes at 13.25±0.71, 12.22 ± 0.68, and 13.11±0.96 g, respectively. In other research, values close to 13.63, 13.40, 12.04 g were found for quails by (15).

The value of the egg number EN in black (Bl) quails increased, which raises hope for achieving better results when carrying out breeding and genetic improvement programs and developing a Bl strain specializing in egg production. Turmeric helps stimulate the secretion of bile by the gallbladder and improve digestion. It also enhances the role of the intestinal microbiota; when curcumin is administered, the mucosal cells increase absorption in the intestine. The addition of turmeric accelerates the attainment of sexual maturity associated with content of phytoestrogens in the turmeric, which has estrogenic effects, and affects growth of the hierarchy of ovarian follicles. The ovulation process takes place directly and all this enhances egg production in quail (21).

It is noted a relatively high coefficient of variation in egg number (EN) which indicates the genetic variation of Syrian quails. This is natural because they are under genetic improvement programs, and so we should be applying breeding and genetic improvement programs aimed at increasing egg production parameters levels, and these. These results are consistent with (21 and 22)

Egg number (EN): estimates in this study were 47.90±3.89, 46.33±3.95, and 43.07± 4.67 egg/two months for the quail. (1) reported similar averages of egg weight (21.84±13.76, 26.85±12.51, and 20.55±14.24 egg/month.

Feed mixtures provided to quail epigenetically affect their offspring and thus, at the incubation stage, affect embryonic responses, which in turn affect metabolism. Embryos are influenced by nutrition and welfare conditions and thus lead to an epigenetic effect in the reprogramming of the embryo genome (9).

Turmeric contains an active compound, curcumin, which contains biological compounds such as flavonoids, alkaloids, terpenoids and polyphenols, which is an antioxidant that reduces oxidative stress in cells such as the cells of the reproductive system and improve the health and functions of the ovaries. It is anti-inflammatory that reduces inflammation and diseases in the bird, improving immunity, which reflects positively on egg production. It also enhances digestion and nutrient absorption by stimulating digestive enzymes secretion, lipase, amylase, and protease. In addition, curcumin positively affects hormones responsible for egg production such as FSH, which stimulates the growth of follicles in the ovaries, LH, which stimulates ovulation, estrogen and progesterone (21).

This table shows how the epigenetic effect through the addition of turmeric in certain concentrations improved the negative side effects of inbreeding. This will help breeders and researchers in future research when applying genetic improvement programmes aimed at creating pure breeds and then genetic hybrids by applying the epigenetic effect in each generation, which reflects positively on the economic return in the poultry industry.

Internal egg quality parameters: Internal egg quality parameters in the three groups of the F4 Syrian quail genotypes (black, striped, and creamy quail) under the epigenetic effects of turmeric powder in diets for the study period are shown in

(Table 2). The parameters are shell weight (SW), shape index (SI), Haugh unit (HU), albumen index (AI), and yolk index (YI)].

Table 2: Epigenetic effects of adding turmeric powder on internal egg quality parameters of three fourth-generation inbred Syrian quail genotype groups (Mean± SD, C.V %).

Parameters	Treatments						Sig. (P)
	Control 0%		Turmeric 1%		Turmeric 2%		
Genotype	X±Sd	C.V%	X±Sd	C.V%	X±Sd	C.V%	
Black quails (Bl)							
SW (g)	1.36±0.16	11.86	1.55±0.19	12.25	1.46±0.15	10.27	N. S.
SI %	77.15±3.08	3.94	79.02±3.89	4.92	78.15±3.22	4.12	**
AW (g)	6.64±0.63	9.51	7.20±0.94	13.05	6.79±0.87	12.81	*
AD mm	39.13±2.78	7.11	40.36±2.23	5.52	39.88±2.53	6.34	N. S.
AH mm	4.75±0.71	14.87	5.11±0.64	12.52	5.23±0.89	17.01	N. S.
YW (g)	3.96±0.37	9.49	4.24±0.46	10.84	4.17±0.58	13.90	N. S.
YD mm	24.83±1.23	4.95	25.77±1.59	6.16	24.95±1.60	6.41	N. S.
YH mm	9.13±0.43	4.70	11.20±0.76	6.78	10.27±0.54	5.25	*
HU	73.83±2.3	3.11	77.13±2.77	3.59	75.70±2.65	3.50	**
AI%	12.31±2.13	17.30	12.66±2.20	17.37	13.11±2.34	17.84	*
YI%	48.85±2.82	5.77	55.01±2.98	5.41	53.18±2.73	5.13	**
Striped quails (St)							
SW (g)	1.29±0.14	10.91	1.30±0.23	17.69	1.28±0.19	14.84	N. S.
SI %	75.93±2.05	2.66	77.08±2.11	2.73	76.13±2.24	2.94	**
AW (g)	6.68±0.64	9.71	8.27±0.57	6.89	7.57±0.71	9.37	N. S.
AD mm	38.88±3.47	8.94	40.54±3.87	9.54	40.11±3.65	9.09	*
AH mm	4.47±0.91	20.12	6.47±1.25	15.84	5.47±1.19	21.75	**
YW (g)	3.83±0.43	11.24	4.71±0.87	18.47	4.65±0.65	13.97	*
YD mm	24.23±1.28	5.31	24.43±1.99	8.14	24.09±1.76	7.30	N. S.
YH mm	9.14±0.39	3.28	11.46±0.55	4.08	11.23±0.48	3.62	*
HU	72.00±6.31	8.76	76.86±6.72	8.74	74.47±5.96	8.00	**
AI%	11.49±2.82	24.54	15.95±2.76	17.30	13.63±2.71	19.88	**
YI%	50.10±2.82	5.62	55.09±3.74	6.78	54.91±3.44	6.26	**
Creamy quails (Cr)							
SW (g)	1.22±0.11	9.41	1.35±0.13	9.62	1.27±0.14	11.02	N. S.
SI%	74.24±3.11	4.18	77.01±3.32	4.26	76.35±3.65	4.78	**.
AW(g)	6.51±0.61	9.31	7.51±0.75	9.98	6.88±0.83	12.06	N. S.
AD mm	40.79±4.26	10.44	43.46±4.47	10.28	42.61±4.33	10.16	*
AH mm	4.13±0.77	18.87	5.26±0.81	15.39	5.34±0.77	14.41	N. S.
YW (g)	3.72±0.43	11.67	5.01±0.67	13.37	4.99±0.68	13.62	**
YD mm	24.32±1.32	5.43	26.55±1.63	6.13	26.11±1.78	6.81	N. S.
YH	9.06±0.43	3.62	11.18±0.55	3.87	10.67±0.73	5.34	*
HU	71.25±6.08	8.53	74.18±6.22	8.39	73.52±6.36	8.65	**
AI%	10.29±2.49	24.21	12.10±2.65	21.90	12.53±2.50	19.95	**
YI%	49.69±2.41	4.83	53.40±2.77	5.18	52.70±2.63	4.99	**

SW: Shell Weight (g), SI: Shape Index (%), AW: Albumen weight (mm), YH: Yolk Height (mm), HU: Haugh Unit, AI: Albumen Index (%), YI: Yolk Index (%).

This study found most parameters registering significant differences at $p<0.05$ of the turmeric epigenetic diets in reducing the negative effects of inbreeding in the three Syrian quail genotypes.

These results diverge from (13) using laying hens but similar to that reported by (25) when adding 0.5-2% turmeric levels to Japanese quail feed which made a significant difference to yolk color, as did another study, except that the turmeric levels were 5-20 ppm (17). (21) showed that using different levels of turmeric powder in quail feed improved protein and calcium metabolism, resulting in improved egg quality. It is noted that the second group recorded higher values for most indicators of internal egg quality in which turmeric was added to the feed at a rate of 1%. Variations between the results of this and other researches may be due to different quail genotypes and turmeric concentrations added to the feed.

The shape index (SI) for the three genotypes reached 74.24±3.11 to 79.02±3.89% for the three groups, which is relatively high, with a small coefficient of variation (C.V) of 2.66 to 4.92%, indicating high genetic similarity due to inbreeding within the genetic improvement program.

The internal quality indices in this study were close to those of previous research in terms of AH (4.58 - 4.13 mm), AW (7.04 - 7.33g), and AI (10.36 - 10.67%) (7), YW (4.83 - 4.40 g) (12,7).

Higher shell weights at 1.22 to 1.55g were recorded in the three groups compared to another study using different levels of turmeric powder in the feed (1.11 -1.19 - 1.20) (21). This may be because turmeric powder improves calcium metabolism.

The Yolk Index (YI) indicates egg freshness, a desirable quality for consumers, recorded higher values of 48.85 to 55.09% in the three groups compared to the 42.06 - 50.0 - 48.63 reported by (7). Yolk height (YH) recorded higher values of 9.06 to 11.46mm in the groups compared to the 9.90 - 10.84 - 9.78 mm of 17,7.

The Albumen Diameter (AD) values were 38.88 to 43.46 in three groups, similar to those reported by (10) of 40.9 to 44.0. Albumen Height (AH) also recorded higher values than those reported by (10). This is an indicator of the Haugh units and, therefore, egg freshness.

The Haugh unit value was relatively high in the genotypes at 71.25 to 77.13 but below the range of reported observations (86.07 - 88.28 - 88.24 - 92.48 - 91.39 - 94.14 by (25).

The study reported highly significant differences at $p<0.01$ in the second group with 1% turmeric of the three quail genotypes studied. Another study (10) found the group with 3% turmeric had the highest significant differences in YW, YH, YD, and SW at 3.65, 12.7, 24.8, and 1.050, respectively. (21) also recorded the highest significant differences in SW, YW, YH, and YD at 1.200, 2.867, 1.033, and 2.348 in the group with 54 mg/quail/day turmeric levels.

This epigenetics study using turmeric powder in Syrian quail feed revealed lower negative effects of inbreeding and improved internal egg quality parameters. A range of studies have explored the impact of environmental factors on the epigenetics of quail. (18). They found no significant trans generational epigenetic variance in egg quality traits, suggesting that current breeding strategies are effective.

The active ingredient in turmeric, curcumin, improves the physiological state of quails and improves liver function by lowering serum glutamic pyruvic transaminase (SGPT) and blood cholesterol levels in their eggs, thereby improving internal egg quality (21).

Gaps and limitations of this research. All environmental conditions should as much as possible be standardized on the study groups to ensure that the only epigenetic effect affecting the experiment is the level of feed addition (turmeric). This will help determine its actual effect on the genetic structures of the experimental birds, the extent of interaction between these genotypes, and the epigenetic effects and amount of improvement resulting from this interaction for supporting the poultry industry.

Phenotypic Correlation: Table 3 shows the correlation values for some internal egg quality characteristics in the three groups of the Syrian quail genotypes studied.

Table 3: Phenotypic correlations in three groups of fourth-generation inbred Syrian quail genotypes.

Phenotypic correlations	EN	EM	SW	ST	EW	AI	YI	SI	HU	YW
Black quail										
EM	.880**									
SW	.393**	.464**								
ST	.400**	.521**	.579**							
EW	-.269**	.692**	.351**	.448**						
AI	-.396**	-.514*	-.507**	-.615**	-.443**					
YI	.229**	.300**	.386**	.480**	.266**	-.594**				
SI	.321**	.377**	.531**	.479**	.286**	-.358**	.472**			
HU	.285**	.392**	.445**	.473**	.364**	-.321**	.396**	.381**		
YW	.381**	.480**	.587**	.659**	.411**	-.634**	.573**	.556**	.497**	
AW	-.197**	.065	-.497**	-.320**	.421**	.280**	-.342**	-.364**	-.222**	-.612**
Striped quail										
EM	.834**									
SW	.345**	.422**								
ST	.412**	.524**	.566**							
EW	-.263**	.666**	.346**	.443**						
AI	-.394	-.517	-.509	-.621	-.447					

	**	*	**	**	**					
YI	.224**	.311**	.381**	.477**	.263*	-.590**				
SI	.324**	.372**	.533**	.471**	.279*	-.354**	.478**			
HU	.280**	.383**	.441**	.471**	.365**	-.319**	.393**	.375**		
YW	.376**	.465**	.573**	.644**	.406**	-.625**	.567**	.558**	.496**	
AW	-.193**	.061	-.484**	-.316**	.424**	.275*	-.339*	-.362*	-.217*	-.604**
Creamy quail										
EM	.856**									
SW	.376**	.454**								
ST	.423**	.512**	.568**							
EW	-.254**	.685**	.343**	.447**						
AI	-.391**	-.524**	-.512**	-.606**	-.425**					
YI	.216**	.306**	.375**	.474**	.273**	-.582**				
SI	.311**	.365**	.535**	.472*	.276*	-.343**	.473*			
HU	.263**	.355**	.427**	.489**	.354**	-.365**	.391**	.374**		
YW	.374**	.476**	.582**	.661**	.423**	-.626**	.563**	.549**	.492**	
AW	-.191**	.057	-.484**	-.316**	.418**	.274*	-.335*	-.357*	-.218*	-.605**

EM: Egg Mass, EN: Egg Number, EW: Egg Weight, HU: Haugh Units.

The table shows positive and negative correlation values of -0.061 to 0.880 in the three quail genotypes in this study, similar to the -0.03 to 0.99 reported by (5 and 14).

The ph. corr. between part-period EN and EM were high and positive at 0.880, 0.834, and 0.856, respectively in three Syrian quail genotypes and generally similar to those reported by (5) in Japanese quail and by (24). Most phenotypic correlation values were low-to-relatively moderate and similar to (6 and 20) though some were high.

Egg numbers had a negative value in the albumen index and weights. Low and negative values were recorded in the yolk index and albumen weight at -0.342, -0.339, and -0.335, respectively in three genotypes, similar to those reported by (22).

Low and positive values were recorded in egg weights and yolk index (0.266, 0.263, and 0.273) respectively for the three genotypes while a negative value of -0.11 was recorded by (22). High and positive values were noted for ST and YW at 0.65. Strong phenotypic correlation coefficients (0.692, 0.659; 0.666, 0.644; and 0.685, 0.661), respectively were observed between EM and EW, ST and YW in the three genotypes (black, striped, and creamy). Part-period EN had negative values with EW of -0.269, -0.263, and -0.254, respectively.

Applying genetic improvement programs in EN.

A positive correlation between EN and EM can produce an improvement in both traits and a decrease in EW due to a negative correlation between them

Weak phenotypic correlation coefficients were observed in the three genotypes between EM and AW at 0.065, 0.061, and 0.057, respectively. The Haugh unit value is an indication of egg quality based on AH values. Estimates of phenotypic correlation for Haugh units were 0.285, 0. 280, and 0263, respectively in the three genotypes, similar to observations by (14). Also, values recorded in this research were close to those of (6 and 20). Deviations in values between this research and others may be due to the different genotypes of the studied local quail. It could also be because it is the fourth generation within a genetic inbreeding improvement programme to establish a pure breed, in addition to the differences in the age of the quail, feed mixtures used, level of turmeric added, and care conditions.

Genotypic Correlation: Table 4 shows estimates of genotypic correlations for some characteristics in the three groups of the inbred Syrian quail genotypes.

Table 4: Genetic correlations for production traits in three fourth-generation inbred Syrian quail genotypes.

Black quail				
Genetic Correlations	EW	YW	SW	**ST**
EW			- 0.274*	**- 0.279***
EM	-0.217	0.556**	0.588**	**0.494**
YW	-0.238*		0.493**	**0.687****
SW				**0.971****
Striped quail				
EW			- 0.258*	**- 0.236***
EM	-0.192	0.453**	0.556**	**0.453****
YW	-0.215*		0.474**	**0.636****
SW				**0.927****
Creamy quail				
EW			- 0.297	**- 0.319***
EM	-0.173	0.516**	0.533**	**0.465****
YW	-0.247*		0.456**	**0.673****
SW				**0.966****

EW: Egg weight, EM: Egg mass, EN: Egg number.

As seen, the correlations were both positive and negative, similar to (2, 5 and 14). Estimates in this study were low to moderate in the three quail genotypes and similar to (2, 6 and 24).

Low and negative values was recorded between traits EM and EW (-0.217, -0.192, and -0.174, respectively) in the three genotypes. Strong genetic correlation coefficients (0.687, 0.636, and 0.673) and (0.588, 0.556, and 0.533), respectively were observed between ShT and YW, Shw and EM, similar to those noted by (24). The other traits recorded positive and low values which were similar to (14).

Quantitative traits are genetically related to each other and transmitted together in the same direction in genetic improvement programmes, whether in inbreeding, outbreeding or selection, starting from the base clan and through several successive generations until the establishment of a pure breed and even after crossing these breeds to obtain hybrids.

Heritability Estimation: Table 5 shows estimates of the heritability coefficient for some traits of egg production of the three inbred Syrian quail genotypes during the peak egg production period of two months 6-7 months old. They are calculated from the correlation between parents and offsprings through the variance components of the generation.

Table 5: Heritability estimates for some trait in three fourth-generation inbred Syrian quail genotypes.

Traits	**Heritability h^2±SE**		
	Black quail	Striped quail	Creamy quail
Part-period (2 months 6-7) average EW	.044±0.08	.039±0.23	.036±0.11
Part period (2 months 6-7) EM	0.63±0.41	0.61±0.07	0.59±0.14
Albumen Weight (AW)	0.19±0.12	0.22±0.12	0.26±0.06
Shell Weight (SW)	0.54±0.17	0.41±0.14	0.39±0.11
Shell Thickness (ST)	0.37±0.09	0.32±0.13	0.38±0.15
Albumen Index (AI)	0.68±0.23	0.52 ± 0.09	0.57±0.08
Yolk Index (YI)	0.58±0.26	0.25 ± 0.08	0.31 ± 0.12
Haugh Units (HU)	0.39±0.09	0.34±0.12	0.36±0.14

EW: weight, EM: Egg Mass, EN: Egg Number.

Table 5 illustrates genetic parameters of some quantitative traits and heritability values from genetic variance components across generations of the three inbred Syrian quail genotypes.

Heritability values ranged from 0.19 to 0.68; high values were recorded for both AI and EM while epigenetic heritability values were a moderate 0.22 to 0.63. Heritability values for genotypes were low-to-moderate and high from 0.22 to 0.68. Similar results were reported by (2) in two strains of Japanese quail.

The moderate heritability coefficient estimates (.044±0.08, .039±0.23, and .036±0.11) of Part-period (2 months) egg weight in this study agrees with those of (6 and 21) but higher than estimates reported by (2) in inbred local quail (white, black, striped, creamy) at 0.19, 0.34, 0.28, and 0.16.

Heritability coefficient values were 0.63±0.41, 0.61±0.07, and 0.59±0.14, respectively for the three Syrian genotypes for egg mass (EM) of the Part-period (2 months), close to that of (20) for Japanese quail.

The heritability of albumen index were moderate at 0.68±0.23. The albumen weight (AW) reported low heritability at 0.19±0.12, 0.22±0.12, and 0.26±0.06, respectively in close to that estimated by (27) for Japanese quail. Heritability estimates for shell weight (SW) had high values of (0.54±0.17, .041±0.14, and .039±0.11), close to that reported by (21). The high-to-moderate heritability in inbred Syrian local quail were close to previously valued estimates (14).

Epigenetic heritability estimates for the Syrian quail studied were low and moderate and shows they are in the fourth generation and have undergone inbreeding for genetic improvements in obtaining pure breeds according to the production plans. This result agrees with the findings of (5).

The epigenetic values for egg production traits were moderate, indicating that epigenetic variation may be heritable.

Heritability expresses the extent to which genes contribute to the phenotypic expression of the trait. The variations in its values are natural and due to the genetic improvement programme employed, the methods of improvement used, and the generation involved. This study used the fourth generation and the method is inbreeding. The genotypes of the quail birds were studied together with the contributions of the cumulative genetic effects in estimation of heritability value and the type of trait. In addition to flock number, which affects experimental error and thus the true estimate of the heritability value and that mating was randomized to achieve flock balance, experimental conditions, care and environmental conditions, such as nutritional factors, temperature, light, and others all contribute to estimates of heritability.

Follow up research and experiments and development plans for new genetic improvement programmes across successive generations with long-term studies and research experiments on each generation should be useful. They should be applied using different genetic and epigenetic methods such as inbreeding or outcrossing on different genotypes with standardized environmental conditions as much as possible. This is to ensure that the only variable is the epigenetic effect (addition of turmeric powder at different levels) to confirm its effectiveness on production, vital and genetic parameters and in reducing the negative side effects of inbreeding. It will also help determine whether this effect is passed down to future generations in order to generalize the results of this study for application to the poultry industry and in expanding its use among poultry breeders as part of the feed mix.

Conclusions

This study investigated whether the application of a genetic improvement programme using inbreeding for several generations to obtain pure breeds with specific production destinations from different color genotypes of fourth generation Syrian local quail caused a decline in production parameters due to inbreeding. The epigenetic effect of adding different levels of turmeric (0, 1, 2%) to quail feed addressed this decrease in production with 1% turmeric offering the best effect in reducing negative effects of inbreeding and improving production and genetic parameters.

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