

Research Article



Effect of Adding Different Levels of Curcumin Powder to the Diet on some Reproductive, Fertility and Hatchability Performance of Broiler Breeders

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Abstract | Twenty roosters and seventy-two laying hens, all 60 weeks old and of the Ross-308 broiler breeder strain, were used in this study. The roosters were divided into 4 treatments, with 5 replicates per treatment, and each replicate containing one rooster. The hens were also divided into 4 treatments, with 18 hens per treatment, each having 3 replicates, with 6 hens in each replicate. Males were fed separately from females. The first treatment (T1) was the control group, fed a basic diet without additives, while treatments (T2, T3, and T4) were fed a diet containing 250, 300, and 350 mg of curcumin powder per kg of feed for the males, and the same additives were used for the females. The results indicated that treatment T4 showed significant ($P \leq 0.05$) superiority in reproductive traits, specifically ejaculate volume and mass, and individual sperm motility, compared with treatment T1, the control. Treatment T4 was also significantly ($P \leq 0.05$) superior to treatments T1, T2, and T3 in sperm concentration rate. Treatments T2, T3, and T4 had significantly higher percentages of live sperm and lower percentages of dead sperm compared to treatment T1. Additionally, treatments T2, T3, and T4 were significantly superior ($P < 0.05$) to treatment T1 in fertilization, hatching, and the percentage of dead embryos. No significant differences were found in the hatching percentage from fertilized eggs or the average chick weight at hatching between treatments. Adding curcumin powder at a rate of 350 mg/kg feed improved semen quality, with treatments T3 and T4 achieving the best fertility and hatching rates.

Keywords | Broiler, Curcumin, Embryo, Fertility, Hatchability, Reproductive

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INTRODUCTION

The increase in meat and egg production depends on the fertility and hatchability of broiler breeders (males and females). Males are important due to their small number, whether insemination is natural or artificial and they are subjected to the interaction of many factors, most im-

portantly are the age of the flock, the breed, the components of the feed, and the efficiency of the semen prepared for insemination. They maintained the species and continued production and reproduction (Fouad *et al.*, 2020). After 50 weeks of egg production, broiler breeders' flocks noticed a decrease and deterioration in the fertility rate. This aging causes poor sperm quality and concentration.

The causes are because of small testicle size or atrophy, low blood testosterone levels, increased body weight, and toxic stress (Lagares *et al.*, 2017).

The most important reason for the decline in fertility in roosters is the conversion of testosterone hormone into estradiol hormone due to the aromatase enzyme, which reduces the secretion of LH and FSH hormones, and its negative effect on sperm production and blood characteristics (Ali *et al.*, 2017; Du *et al.*, 2021). There are feed materials with a natural content of antioxidants that enhance the ability of elder and stressed roosters to improve fertilization and hatching (Khalil-Khalili *et al.*, 2021; Ahmad and Emad, 2023). Emad and Sabreen (2022) also showed that the use of medicinal plants has a significant impact on the reproductive characteristics of broiler breeders. Among these plants is curcumin, which is a yellow or orange substance that contains natural polyphenols obtained from turmeric roots which is the reason for the yellow color of turmeric. It has attracted the attention of scientists in recent years because its natural antibiotic is important for improving the growth of poultry and livestock species and is considered disease-resistant as well (Pan *et al.*, 2022; Sureshbabu *et al.*, 2023).

The use of curcumin has led to remarkable results for poultry flocks, it showed improvement in digestion and the required growth, improved immune functions, and increased fertility. Also, it is considered a therapeutic substance and antioxidant that treats inflammation and joints and resists stress (Moniruzzaman *et al.*, 2021). It confirmed that the use of curcumin in the poultry diet has led to an increase in fertilized eggs, an increase in the hatching rate and the weight of chicks at hatching, and a decrease in dead embryos (Wakjira *et al.*, 2021). Curcumin is a nutritional and therapeutic element for poultry and livestock, so nutritionists prefer curcumin as an alternative to chemical additives, as it improves body health while achieving economic benefits (Placha *et al.*, 2022; Shehata *et al.*, 2022). Thuy and Ha (2022) found that adding curcumin to laying hens' diet increased egg production and size, increased egg yolk quality and color intensity, and improved fertility and hatchability. This study aims to investigate the effect of different levels of curcumin powder in the diet on semen characteristics, fertility, and hatchability in broiler breeder males. The goal is to determine the optimal concentration for roosters and the best concentration of curcumin powder to feed females used in artificial insemination.

MATERIALS AND METHODS

The experiment was conducted at the poultry farm, Department of Animal Production, College of Agriculture, Al-Qassim Green University, over a period of 14 weeks from 1/11/2023 to 8/2/2024. A total of 20 roosters and

72 laying hens, each 60 weeks old, were used in this study. The average weight of the roosters was 5.5 kg, and the hens weighed 4.5 kg. The roosters were randomly distributed into wooden cages surrounded by soft wire mesh (0.75 cm * 1.0 m), while the hens were randomly distributed into wooden cages with BRC wire mesh (1.5 m * 1.0 m), following a floor breeding system. Sawdust, 7 cm in height, was used to cover the floor of all cages.

The lighting system provided 14 hours of light and 10 hours of darkness per day, starting from 6 am to 8 pm throughout the experiment. Feed was provided at a rate of 120 g/day for all replicates, containing curcumin, from the first day of the experiment for both males and females separately, except for the control treatments, which received no curcumin. The treatments used in this study were as follows: (T1) no curcumin added; (T2, T3, and T4) diets with 250, 300, and 350 mg/kg of curcumin powder, respectively. The experimental diet used in this study is shown in Table 1.

Table 1: Nutrient composition of experimental diets.

Calculated chemical composition	Females	Males
Crude protein (%)	15.73	13.9
Representative energy (kilocalorie/kg feed)	2873	2771

* The amounts of energy and protein were calculated according to the company's instructions (Ross 2022).

ADDING CURCUMIN TO THE DIET

Curcumin powder was purchased from the pharmacy which is a product of the American company NOW. The box contained 60 capsules of yellow curcumin powder. After emptying the capsules and weighing the substance with a sensitive scale, the required proportions were mixed with the feed, a small amount of feed, then more and more, until it was mixed with all the feed for each treatment and according to the required quantities. Then it was formed into a pellet after returning it to the crusher, and then fed to the birds (females and males).

ARTIFICIAL INSEMINATION

The semen of each rooster was collected and then mixed for each treatment, making up 1 ml of semen, 2 ml of glucose, and 2 ml of low-fat sorting milk (Ali *et al.*, 2017). Females were inseminated after 2pm in the afternoon. Each group of females was inseminated by males (fed the same diet).

SEMEN QUALITY ANALYSIS

Semen was collected from the roosters three times a week by massaging the back and abdomen. One person held the rooster and gently extended its head backward to expose the cloaca. Another person then massaged the dorsal and abdominal areas, starting from the back and continuing to the base of the tail. After the massage, pressure was applied to the cloacal opening, allowing the semen to flow out and

be collected in a graduated microtube (up to 1.5 ml). The collected semen was immediately placed in an incubator set at 37°C to maintain sperm vitality.

To measure the ejaculate volume, a plastic microtube graduated from 0 to 1.5 ml was used. The tube, which had a plastic cap, was pre-warmed in the incubator (37°C) to help preserve the sperm and accurately measure the ejaculate.

Sperm motility was assessed using the method described by Parker *et al.* (1942). Individual sperm movement was also evaluated according to Parker's method (1942). Sperm concentration was determined using Al-Daraji's method (2013), and the percentage of dead sperm was calculated following the procedure outlined by Lake and Mohan *et al.* (1978).

FERTILITY AND HATCHING PERFORMANCE

The females were inseminated during two periods: the first insemination occurred in the ninth week of the study, twice a week, and the second insemination took place in the thirteenth week, also twice a week. Eggs were collected for 7 days following each insemination, and 240 eggs were selected for the first and second hatches after each period of insemination. The inseminations were conducted after 2 pm to ensure that the oviduct was empty of any eggs that could obstruct the reproductive tract and prevent fertilization. The following characteristics were then assessed according to the method of Naji and Aziz (1999): egg hatching rate, fertilization rate, hatching rate, hatchability rate of fertilized eggs, percentage of dead embryos, and the weight of newly hatched chicks.

STATISTICAL ANALYSIS

The data were analyzed using a completely randomized design (CRD) to examine the impact of the studied parameters on the various traits. Significant differences between the means were assessed using Duncan's test (1955).

RESULTS

The current experiment lasted for 14 weeks, with the roosters starting at 60 weeks of age. Weeks 61 and 62 were without semen withdrawal. The remaining weeks were divided into six durations, each lasting two weeks (Duration 1, Duration 2, Duration 3, Duration 4, Duration 5, and Duration 6). In each duration, semen was withdrawn three times during the first week, and there was no withdrawal during the second week. By the end of the experiment, the roosters were 74 weeks old.

EJACULATE VOLUME (ML)

Table 2 presents the effect of adding different levels of curcumin powder to the diet on ejaculate volume (ml). No

significant differences were observed between treatments in weeks 3, 5, and 7 of the experiment regarding ejaculate volume. Treatment T4, with a level of 350 mg/kg feed, showed the highest ejaculate volume, being significantly superior ($P \leq 0.05$) in week 9 compared to the other treatments. In week 11, no significant difference was found between treatments T1 and T2, both of which showed a significant decrease ($P \leq 0.05$) compared to treatments T3 and T4, which did not differ significantly from each other. In week 13, the results indicated a significant improvement ($P \leq 0.05$) in ejaculate volume for the supplemented groups (T4, T3, and T2), with no significant difference between these groups and treatment T1 (control).

Table 2: Effect of adding different levels of curcumin powder to the diet on the ejaculate volume (ml) of Ross-308 broiler breeder roosters (mean ± SE).

Treat-ments	Ejaculation volume (ml)					
	Week3	Week5	Week7	Week9	Week11	Week13
T1	0.42 ±0.03	0.52 ±0.03	0.54 ±0.04	0.40 ±0.03 ^b	0.38 ±0.04 ^c	0.52 ±0.02 ^b
T2	0.43 ±0.02	0.46 ±0.02	0.50 ±0.03	0.36 ±0.02 ^b	0.34 ±0.02 ^c	0.56 ±0.02 ^{ab}
T3	0.44 ±0.05	0.48 ±0.04	0.66 ±0.09	0.40 ±0.03 ^b	0.44 ±0.04 ^{ab}	0.64 ±0.08 ^{ab}
T4	0.46 ±0.04	0.42 ±0.06	0.66 ±0.11	0.50 ±0.00 ^a	0.48 ±0.02 ^a	0.72 ±0.07 ^a
P-value	NS	NS	NS	*	*	*

Different letters indicate significant differences for the same column* ($P \leq 0.05$). NS: indicates no significant differences. Treatments: T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at 250, 300, and 350 mg/kg feed respectively.

TOTAL SPERM MOTILITY %

Table 3 shows that no significant differences were observed between the treatments during weeks 3 and 5 for sperm motility percentage. However, in week 7, a significant improvement ($P \leq 0.05$) was noted for the supplemented groups, with no significant differences among them compared to treatment T1. In week 9, a highly significant superiority ($P \leq 0.01$) was observed for treatment T4 compared to the other treatments, which did not differ significantly from each other. In week 11, treatments T3 and T4 were significantly superior ($P \leq 0.01$) compared to treatment T1, while no significant differences were observed between T1 and T2, nor between T2 and the supplemented treatments (T3 and T4). In week 13, no significant differences were found between treatments T3 and T4, both of which were significantly superior ($P \leq 0.01$) to treatments T1 and T2. No significant differences were found between T1 and T2. It was noted that treatment T4, with a level of 350 mg/kg feed, recorded the best sperm motility rates in weeks 7, 9, 11, and 13.

Table 3: Effect of adding different levels of curcumin powder to the diet on collective sperm motility in Ross-308 broiler breeder roosters (mean $\pm$ SE).

Treat-ments	Collective sperm motility (%)					
	Week3	Week5	Week7	Week9	Week11	Week13
T1	77.8 ± 1.02	81.6 ± 3.81	80.0 $\pm 2.73^b$	81.2 $\pm 1.82^b$	78.6 $\pm 1.40^b$	79.6 $\pm 0.40^c$
T2	77.0 ± 1.95	87.0 ± 1.22	83.4 $\pm 1.86^{ab}$	81.4 $\pm 0.67^b$	84.2 $\pm 1.24^{ab}$	83.2 $\pm 1.65^{bc}$
T3	81.6 ± 4.03	85.0 ± 2.23	83.0 $\pm 1.22^{ab}$	82.6 $\pm 1.21^b$	86.0 $\pm 2.19^a$	85.6 $\pm 1.96^{ab}$
T4	83.4 ± 1.91	89.0 ± 1.87	87.2 $\pm 2.61^a$	90.0 $\pm 1.58^a$	90.0 $\pm 2.68^a$	91.2 $\pm 2.72^a$
P-value	NS	NS	*	**	**	**

Different letters indicate significant differences for the same column* ($P \leq 0.05$), ** ($P \leq 0.01$). **NS:** indicates no significant differences. **Treatments:** T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at the levels of 250, 300, and 350 mg/kg feed respectively.

Table 4: Effect of adding different levels of curcumin powder to the diet on individual sperm motility in Ross-308 broiler breeder roosters (mean $\pm$ SE).

Treat-ments	Individual sperm motility (%)					
	Week3	Week5	Week7	Week9	Week11	Week13
T1	69.00 ± 1.00	72.40 $\pm 2.23^b$	72.00 $\pm 1.22^b$	73.20 $\pm 2.80^b$	68.80 $\pm 1.46^c$	69.60 $\pm 0.40^c$
T2	65.60 ± 1.80	71.80 $\pm 0.80^b$	73.80 $\pm 1.74^{ab}$	77.00 $\pm 1.22^{ab}$	74.40 $\pm 1.12^b$	73.20 $\pm 1.49^b$
T3	70.40 ± 5.10	73.20 $\pm 1.24^b$	74.00 $\pm 1.00^{ab}$	77.00 $\pm 2.00^{ab}$	77.20 $\pm 1.80^b$	75.60 $\pm 1.96^b$
T4	72.60 ± 2.04	80.40 $\pm 2.37^a$	79.40 $\pm 2.97^a$	81.00 $\pm 1.87^a$	83.00 $\pm 1.38^a$	84.00 $\pm 1.00^a$
P-value	NS	**	*	*	**	**

Different letters indicate significant differences for the same column* ($P \leq 0.05$), ** ($P \leq 0.01$). **NS:** indicates no significant differences. **Treatments:** T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at the levels of 250, 300, and 350 mg/kg feed respectively.

INDIVIDUAL MOTILITY %

Table 4 shows no significant differences between the treatments in week 3. However, treatment T4 was significantly superior ($P \leq 0.01$) to the other treatments. In week 5, no significant differences were observed between the treatments. For weeks 7 and 9, treatment T4 demonstrated a significant superiority ($P \leq 0.05$) compared to treatment T1, but no significant differences were found between the other treatments. In weeks 11 and 13, treatment T4 exhibited highly significant superiority ($P \leq 0.01$) over the other

treatments. Additionally, no significant differences were observed between treatments T2 and T3, which were significantly superior ($P \leq 0.01$) to treatment T1. Therefore, treatment T4 (350 mg/kg feed) was the most effective for weeks 7, 9, 11, and 13.

Table 5: Effect of adding different levels of curcumin powder to the diet on sperm concentration ($X \cdot 10^9$ per ml) in Ross-308 broiler breeders (mean $\pm$ standard error).

Treat-ments	dura-tion 1	dura-tion 2	dura-tion 3	dura-tion 4	duratio 5	dura-tion 6
	63-64 weeks	65-66 weeks	67-68 Weeks	69-70 Weeks	71-72 weeks	73-74 weeks
T1	83.60 ± 4.15	12.44 ± 17.0	11.94 ± 13.0	18.60 ± 6.78	12.78 $\pm 9.56^b$	14.18 $\pm 4.36^b$
T2	83.60 ± 9.66	13.30 ± 15.0	15.60 ± 22.7	18.08 ± 7.36	13.56 $\pm 6.54^b$	15.04 $\pm 1.69^b$
T3	90.00 ± 9.60	15.62 ± 3.9	16.36 ± 24.3	18.40 ± 11.66	14.48 $\pm 4.70^b$	15.46 $\pm 3.67^b$
T4	87.20 ± 5.59	16.10 ± 4.9	17.34 ± 16.3	17.90 ± 14.38	16.46 $\pm 10.06^a$	17.88 $\pm 13.69^a$
P-value	NS	NS	NS	NS	*	*

Different letters indicate significant differences for the same column* ($P \leq 0.05$). **NS:** indicates no significant differences. **Treatments:** T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at 250, 300, and 350 mg/kg feed respectively.

SPERM CONCENTRATION ($X \cdot 10^9$ /ML)

Table 5 shows no significant differences between the treatments in weeks 3, 5, 7, and 9 in terms of sperm concentration rate. However, in weeks 11 and 13, treatment T4 was significantly higher ($P \leq 0.05$) compared to the other treatments, with no significant differences observed between the other treatments. Therefore, T4 (350 mg/kg feed) was the most effective treatment in weeks 11 and 13.

DEAD SPERM PERCENTAGE

Table 6 presents the effect of adding curcumin powder to the diet on the number of dead sperm. The results indicate that no significant differences were found between treatments in week 3. In week 5, treatment T1 was significantly superior ($P \leq 0.01$) to the other treatments, while treatment T2 was significantly higher compared to treatment T4. No significant differences were observed between treatments T2 and T3, or between treatments T3 and T4. In week 7, treatments T1 and T2 were significantly superior ($P \leq 0.05$) over treatments T3 and T4, with no significant differences between the latter two. In week 9, treatment T4 showed a significant decrease ($P \leq 0.05$) compared to treatment T2, but no significant differences were found between treatments T1 and T3. In weeks 11 and 13, there were no significant differences between treatments T1, T2, and T3, all of which showed a highly significant superiority ($P \leq 0.01$)

over treatment T4. Thus, treatment T4 recorded the lowest rate of dead sperm in weeks 5, 7, 9, 11, and 13.

Table 6: Effect of adding different levels of curcumin powder to the diet on the dead sperm percentage of Ross-308 broiler breeder roosters (mean $\pm$ SE).

Treatments	Dead sperm percentage					
	Week3	Week5	Week7	Week9	Week11	Week13
T1	18.8 ± 1.20	16.0 $\pm 0.83^a$	11.6 $\pm 0.67^{ab}$	11.0 $\pm 1.00^{ab}$	15.6 $\pm 1.21^a$	16.6 $\pm 1.86^a$
T2	19.2 ± 4.36	12.6 $\pm 1.12^b$	14.0 $\pm 1.81^a$	13.2 $\pm 1.11^a$	15.0 $\pm 1.04^a$	14.8 $\pm 0.48^a$
T3	13.2 ± 0.96	12.0 $\pm 1.00^{bc}$	10.4 $\pm 0.51^b$	10.4 $\pm 1.28^{ab}$	12.6 $\pm 1.46^a$	12.6 $\pm 2.11^a$
T4	13.2 ± 0.80	9.20 $\pm 0.86^c$	9.4 $\pm 0.40^b$	9.8 $\pm 0.48^b$	8.6 $\pm 0.67^b$	7.8 $\pm 0.37^b$
P-value	NS	**	*	*	**	**

Different letters indicate significant differences for the same column* ($P \leq 0.05$), ** ($P \leq 0.01$). NS: indicates no significant differences. **Treatments:** T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at 250, 300, and 350 mg/kg feed respectively.

Table 7: Effect of Different Levels of Curcumin Powder in the Diet on Fertility and Hatchability Traits (%) in Ross-308 Broiler Breeder Roosters for the First and Second Hatch.

	Treatments				P-value
	T1	T2	T3	T4	
First Hatch Traits					
Fertility (%)	81.66 ^b	86.66 ^{ab}	90.00 ^a	85.00 ^{ab}	*
Hatching (%)	71.66 ^b	76.66 ^{ab}	81.66 ^a	75.66 ^{ab}	*
Hatching from fertilized eggs (%)	87.75	88.46	90.74	88.23	NS
Dead embryo (%)	12.24 ^a	11.53 ^a	9.25 ^b	11.76 ^a	*
Chick average weight at hatching (g)	41.1	42.11	42.18	42.13	NS
Second Hatch Traits					
Fertility (%)	76.66 ^b	88.33 ^a	86.66 ^a	86.66 ^a	*
Hatching (%)	66.66 ^b	80.00 ^a	78.33 ^a	78.33 ^a	*
Hatching from fertilized eggs (%)	86.95	90.56	90.38	90.38	NS
Dead embryo (%)	13.04 ^a	9.43 ^b	9.61 ^b	9.61 ^b	*
Chick average weight at hatching (g)	13.04	9.43	9.61	9.61	NS

Different letters indicate significant differences for the same row* ($P \leq 0.05$). NS: indicates no significant differences. **Treatments:** T1 control treatment without any addition, T2, T3, and T4 treatments adding curcumin powder to the diet at 250, 300, and 350 mg/kg feed respectively.

FERTILITY AND HATCHABILITY TRAITS (%)

Fertility and hatchability traits (%) in Ross-308 broiler

breeder roosters for the first and second hatch are summarized in Table 7. An increase ($P \leq 0.05$) in fertility and hatching percentages, along with a decrease ($P \leq 0.05$) in the percentage of dead embryos, was observed in the T3 group compared to the other groups. No significant effect ($P > 0.05$) was found on the hatching percentage from fertilized eggs or the average chick weight at hatching.

DISCUSSION

The current study showed an improvement in some characteristics such as ejaculate volume, individual and collective motility, concentration and number of live sperm, and a decrease in dead sperm for treatments that used curcumin powder in their diet. Yan *et al.* (2017) explained that curcumin has antioxidant properties that improve the integrity of sperms and their general shape by maintaining their plasma membrane and thus improving their ability to move collectively and individually, but the curcumin should be added in small proportions. This was an agreement and disagreement at the same time with Jalili *et al.* (2020), who found that when curcumin added, it was preserved the integrity of the acrosome plasma membrane of sperm, which was the reason for improving sperm motility, but high doses of added curcumin to the diet achieved the best sperm motility. This may be due to the active components in curcumin, which caused a gradual increase in the diameter of the seminiferous tubule and increased its components, as well as an increase in the number of Leydig cells, which may be the reason for increasing the ejaculate volume, sperm concentration, and their motility (Fouad *et al.*, 2020).

The contamination of sperm that occurs during collection, insemination, and storage which is caused by the contamination of the collection area with bacteria such as *Salmonella* and *Escherichia coli* (*E. coli*) is transmitted to the semen after adhering to the sperm, especially the middle and tail area of the sperm, and that lead to weakening the semen and the general deterioration of its characteristics as well as reduction in sperm motility (Mezhoud *et al.*, 2015; Lenický *et al.*, 2021). These bacteria also have a high ability to adhere to mannose receptors on the surface of the sperm, which reduces energy on the one hand, and on the other hand, these bacteria form hairs that break down the sperm plasma membrane (Benoff *et al.*, 2000; Stones and Krachler, 2016).

Harmful bacteria work to reduce oxidative phosphorylation inside the energy houses (mitochondrion), thus weakening the mitochondrial membrane, which is considered the most important factor for the movement and activity of sperm (Fraczek *et al.*, 2012). These bacteria also secrete lipopolysaccharide (LPS), which is one of the parts of the negative bacteria cell wall and one of the most internal tox-

ins caused by these bacteria. Its function is gene expression that activates the death of programmed cells and reduces the phosphorylation of proteins that are necessary for the movement and vitality of sperm (Prabha *et al.*, 2010; Berger *et al.*, 2019).

LPS is a strong oxidation agent and one of the most important causes of excessive ROS production, which reduces sperm concentrations, movement, and activity (He *et al.*, 2017), so it is proven that adding curcumin protected sperm and their safety through its interactive behavior with the lipid layer presented in sperm membranes and preventing changes in them, as well as stimulating mitochondria to produce the energy needed for sperm movement, as well as scavenging free radicals (Omur and Cayan, 2016; Santonastaso *et al.*, 2021). Curcumin can also attack the walls and plasma membranes of bacteria, their DNA, and cell proteins, and adhere to their receptors, forming biofilms that prevent their development. It may also increase energy production, semen expansion, the movement and percentage of live sperm, and reduce dead sperm (Gholami *et al.*, 2020; Tvrdá *et al.*, 2022).

Curcumin works as an antioxidant because it contains double bonds between carbon atoms (C=C) in addition to the presence of the "β-diketo" group and phenyl rings that are connected with methyl and hydroxyl). With this structure, curcumin provides an H atom from the methyl group and bis-dimethoxy curcumin, making it a good antioxidant. These properties improve the general health of roosters and reflect the performance of the reproductive system, thus improving the quality of semen (Tanvir *et al.*, 2017; Boroumand *et al.*, 2018).

However, its bioavailability improves the function of the digestive tract of roosters by encouraging the growth of beneficial microorganisms and reducing the severity of inflammation, stress, parasites, and fungi. This may make curcumin work similar to the work of probiotics and prebiotics, which are reflected in the health of the body in general, including the reproductive system, and thus improve the characteristics of semen (Pandey *et al.*, 2015; Lopresti, 2018). Emad and Sabreen (2022) stated that improving the aromatase enzyme using an aromatase inhibitor improved sperm motility as well as sperm concentration and reduced dead sperm in broiler breeder roosters. The use of medicinal plants reduces the conversion of part of the testosterone hormone to estrogen in males of laying hen breeders.

CONCLUSIONS AND RECOMMENDATIONS

Adding curcumin powder at a rate of 350 mg/kg feed (T4) yielded the best results in improving semen quality, includ-

ing ejaculate volume, individual and group sperm motility rate, sperm concentration, and the highest number of live sperm, along with the lowest rate of dead sperm. Treatment T3, with curcumin powder at a rate of 300 mg/kg feed, achieved the best fertility rates, hatching percentages, and the lowest percentage of dead embryos.

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NOVELTY STATEMENT

The novelty of our study lies in providing strong evidence that curcumin powder improves the reproductive characteristics of Ross-308 broiler breeders, marking the first such finding.

AUTHOR'S CONTRIBUTIONS

All authors contributed equally.

CONFLICT OF INTEREST

None.

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