THE EFFECT OF ROSEMARY (SALVIA ROSMARINUS) SUPPLEMENTED DIET ON REPRODUCTIVE AND PRODUCTIVE TRAITS OF LIBYAN LOCAL PIGEON

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ABSTRACT

The objective of this study was to investigate the effect of rosemary leaves powder supplement on reproductive and productive performance of local pigeon. Thirty pairs of Libyan local pigeons were randomly allocated into three groups, each with 10 replicates. Rosemary leaves powder (RLP) was added to isonitrogenous and isoenergetic ration at 0 % (control, C), 0.5 % (T1) or 1 % (T2). The experiment lasted for a complete breeding cycle. RLP did not affect egg weight, egg number or incubation period. Egg volume (13.82, 10.73 and 11.42 cm$^3$), egg hatchability (100, 55.56 and 50.00 %) and hatching weight (16.63, 14.91 and 14.89 g) were higher in C group in comparison with T1 and T2, respectively (p < 0.05). Egg surface area (30.25, 26.30 and 27.74 cm$^2$) and egg width (2.67, 2.44 and 2.53 cm) were higher in C than in T1 (p < 0.05) and tended to be higher than T2 (p > 0.05). Egg length, egg shape index, fertility rate and pre-weaning survival rate tended to decrease with the increased RLP inclusion rate; however, these differences were not significant (p > 0.05). Squab weight at weaning was lower in C than in T2 group, (310.35, 312.08, 337.98 g for C, T1, and T2, respectively) (p < 0.05). Peroxide value of fresh meat tended to decrease in T2 compared to T1 or C groups (0.6, 0.49, 0.37 meq/kg for C, T1 and T2, respectively) (p > 0.05). Malondialdehyde (MDA) concentration in fresh meat (0.16, 0.16, 0.09 mg MDA/kg) and blood (1.66, 0.83, 0.61 mg MDA/L) for C, T1 and T2, respectively, was lower in T2 compared to C group (p < 0.05). In conclusion, adding RLP to feed negatively affected the reproductive performance despite expected improvement of the productive performance and oxidative status in pigeons.

Key words: pigeon; rosemary; reproduction; production; oxidative stress

INTRODUCTION

North Africa is one of the native homes for rock pigeon (Columba livia) (Shapiro and Domyan, 2013). Domestic pigeons descend from rock pigeons (Gilbert and Shapiro, 2013). Nowadays, domestic pigeons could be divided into three categories: flying, fancy and utility pigeons (Harlin, 1994). The pigeon is a monogamous bird that breeds all year round, with peak fertility during spring and summer (Johnston and Janiga, 1995). Pigeons are altricial birds in which squabs depend on both parents until weaning (Dumont, 1965). In comparison with other poultry species, information about the nutritional requirements of the domestic pigeon is limited. This may be attributed to the nutritional dependency of squabs on their parents until weaning (Sales and Janssens, 2003). Abou Khashaba et al. (2009) reported that protein levels of 14–16 % and energy of about 2800 Kcal.kg$^{-1}$ of diet could meet the productive and reproductive requirements of pigeons in different seasons. Aromatic plants and their derivatives have
been used as feed additives in poultry due to their potential antimicrobial properties, improving nutrient digestion, enhance immune system and antioxidant capacity (Jin et al., 2020). Rosemary is one of widely investigated aromatic plants in poultry nutrition and it was reported to increase weight gain in broilers (Ghazalah and Ali, 2008) and quails (Sarmad et al., 2020), improve the physical characteristics of eggs (Abo Ghanima et al., 2008; Borghei-Rad et al., 2017). However, studies of rosemary feed supplement effect on pigeon’s reproductive and productive performance are still limited (Dal Bosco et al., 2005). The variation of egg volume and shape within the same species could be a result of food quality and weather conditions, and this variation in volume and shape could affect squab mortality (Janiga, 1996). Measurements of egg weight, shape, volume and surface area are considered important indicators in the poultry industry and biological studies, and these measurements correlate with hatchability and hatch weight (Narushin, 2005). Reproductive and productive performance of Libyan pigeons are not well documented in comparison with other poultry species, especially broiler and layer chickens.

The objective of this study is to evaluate the effect of the inclusion of rosemary leaves as a feed additive on the productive and reproductive performance of Libyan pigeons. In addition, the reproductive and productive traits, determined in this study, could be considered as a reference to Libyan pigeon as long as these traits concerned.

MATERIAL AND METHODS

This study was conducted at the animal house of Faculty of agriculture, Omar Al-Mukhtar University, Libya. The room was 4 x 6 m and 3 m in height. Cages were 30 cm long, 23 cm wide and 20 cm in height and equipped with feeders and waterers. Before an arrival of the birds, the room was cleaned with disinfectants, the ceiling and walls were painted with lime and sprayed with insecticide, then closed for 24h. Thirty pairs of Libyan pigeons 12–24 months of age were purchased from local farmers. Birds were adapted to the experimental room for 30 days, during this period the birds received the control diet. Proper heater was used to maintain room temperature around 20 °C. Iso-nitrogenous and iso-caloric diets were prepared in pelleted form in a private feed factory. Rosemary plant was obtained from Al-Bayda suburbs. The plant was dried in a shade with a well-ventilated place without applying any heat treatment. After dryness, the leaves were separated from branches and ground to the fine powder. Rosemary leave powder was mixed with a ration during feed manufacturing.

Diet ingredients and chemical composition are presented in Table 1. Water was provided ad libitum and feed quantity was adapted to feed intake. The experiment began in November 2019 and ended in January 2020.

Pigeon pairs were randomly allocated to three groups: control (C) and two treatments groups (T1 and T2), with 10 replicates per each group. Pairs (male and female) of each group were randomly distributed to cages. The control group received the standard diet, and the other two treatment groups T1 and T2 received rosemary powdered leaves either at 0.5 % or 1 % of the ration, respectively.

Table 1. Ingredients and chemical composition of experimental diet

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>66</td>
</tr>
<tr>
<td>Wheat grain</td>
<td>10.5</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>18.6</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.2</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>2.4</td>
</tr>
<tr>
<td>Salt</td>
<td>0.3</td>
</tr>
<tr>
<td>Vitamin-mineral mix*</td>
<td>1.0</td>
</tr>
<tr>
<td>Chemical composition</td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>88</td>
</tr>
<tr>
<td>Crude protein</td>
<td>15.5</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>2.71</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.88</td>
</tr>
<tr>
<td>Ash</td>
<td>1.00</td>
</tr>
<tr>
<td>Soluble carbohydrates</td>
<td>76.91</td>
</tr>
<tr>
<td>ME** (MJ.kg⁻¹ diet)</td>
<td>13.36</td>
</tr>
</tbody>
</table>

*Vitamin-mineral mix compose of (kg): Vit A. 1000000 IU, D₃ 300000 IU, E 5000 mg, B₃ 500 mg, B₄ 400 mg, B₅ 400 mg, B₉ 2 mg, K 12.5 mg, C 2500 mg, Nicotinic acid 1500 mg, Calcium pantothenate 2000 mg, Choline chloride 25000 mg, Methionine 3500 mg, Lysine 10000 mg, NaCl 9800 mg, Mg 3000 mg, Mn 3150 mg, Zn 5100 mg, Fe 3100 mg, Cu 250 mg, Co 247 mg, I 137.6 mg, Dical. Phosphate 68300 mg.

** Estimated from the sum of ingredients ME.
Measurements

Egg weight, hatching and weekly weight until weaning on 28 days were recorded using a digital precise balance (XB320 M Precisa Instruments, Dietikon, Switzerland). In addition, clutch size and incubation period were recorded. Egg length and width were recorded by calibre Vernier and the following parameters were obtained:

- Egg volume (cm³) = 0.51 . egg length . (egg width)² (Hoyt, 1979)
- Egg shape index (%) = egg width/egg length . 100 (Narushin and Romanov, 2002)
- Egg surface area (cm²) = (3.155 − 0.0136 . egg length + 0.0115 . egg width) . egg length . egg width (Narushin, 2005)

Fertility: The eggs that were not hatched or abandoned by the parents were examined and fertility was calculated as follows:

Fertility (%) = N. of fertilized eggs/N. of total eggs . 100

Hatchability was assessed as follows:

Hatchability (%) = N. of squab hatched/N. of total eggs . 100

Chemical analysis

Proximate analysis of diet was done according to AOAC protocol (AOAC 2000).

Total Phenols in the ground rosemary leave sample were determined according to Singleton and Rossi (1965). The results were expressed as milligrams of Gallic acid equivalent (GAE) per gram of sample dry matter.

Total Flavonoids in the ground rosemary leave sample were determined according to the approach proposed by Yoo et al. (2008) and expressed as milligrams of Catechin equivalent (CE) per gram of sample dry matter.

Finally, Oxidative stress marker analysis was done as follows: At the end of the experiment, 5 squabs were randomly chosen from each treatment and killed. Samples of blood and meat were taken for determination of Malondialdehyde (MDA) by TBA assay according to the methods of Placer et al. (1966) and Vyncke (1970), respectively.

Data were subjected to a statistical analysis using the SYSTAT 13 software © (Copyright 2009, Systat Software, Inc.). The data were analysed based on a one-way analysis of variance. Treatment means were then compared by LSD (Least Significant Differences) test at p < 0.05 significance level. Hatchability, fertility and mortality rates were subjected to a Chi-square test (χ²) at p < 0.05 significance level.

RESULTS AND DISCUSSION

Total phenols and flavonoids in rosemary leaves

The content of phenols and flavonoids in rosemary leaves is shown in Table 2. Rosemary leaves used in this study contained 76.97 mg GAE.g⁻¹ of total phenols and 49.90 mg CE.g⁻¹ of flavonoids. Antioxidant capacity of rosemary is related mainly to its content of phenols and flavonoids (Yeddes et al., 2019). In comparison with our results, studies in Algeria and Tunisia (two neighboured countries) recorded lower concentrations of total phenols and flavonoids in rosemary leaves when we consider a change of their results from mg GAE.g⁻¹ extract to mg GAE.g⁻¹ of the sample (Hendel et al., 2016; Yeddes et al., 2019). This variation may be due to intrinsic factors of the plant itself or to geographical location, plant maturity stage, pre-extraction treatment and extraction conditions (Pérez et al., 2007; Yeddes et al., 2019; Aljabri, 2020).

Effect of rosemary supplement on the productive performance of Libyan pigeons

Rosemary supplement decreased squab hatching weight (Table 3.). Increasing rosemary supplement from 0.5 to 1 % in the diet did not affect hatching weight (p > 0.05). After hatching, the effect

| Table 2. Total content of phenols and flavonoids in rosemary leaves |
|---|---|---|
| | Total phenols* | Total flavonoids ** |
| Rosemary leaves | 76.97 | 49.90 |

*mg GAE/g of sample, ** mg CE/g of sample
of rosemary supplement changed. The body weight of birds in C group was lower than the body weight of the birds in T1 and T2 groups from two-week age until weaning (p < 0.05). Hatching weight in broilers is highly correlated with egg weight, however, the growth in the stage that follows hatching, especially from the fifth day onward, was not affected by egg weight, and was highly influenced by nutrition (Pinchasov, 1991).

Studies have shown that rosemary supplements may enhance weight gain in broilers (Al-Kassie, 2008; Ghazalah and Ali, 2008) and quails (Sarmad et al., 2020). However, Sarmad et al. (2020) stated that the inclusion of rosemary into the diet at 0.5 and 1 % was better than that of 2.5 %. Interestingly, the same results were reported by ElNaggar et al. (2016). Several reports, on the other hand, mentioned that rosemary supplements may not improve weight gain in layers (Alagawany and Abd El-Hack, 2015) and broilers (Ghizlan et al., 2017; Abd El-Latif et al., 2013). Thus, Ghizlan et al. (2017) demonstrated that the inclusion of rosemary into the diet at more than 0.5 % had negative effect on the productive performance of broilers. Contrarily, our results showed that rosemary supplement improved the growth performance of squabs.

Sarmad et al. (2020) concluded that the effect of rosemary on the improvement of growth in quails could be attributed to the natural antioxidants in rosemary (Etter, 2005; Nieto et al., 2018), and this may explain the improvement in growth rate we observed in our experiment. It is noteworthy that oxidative stress in domestic birds leads to many diseases that affect their growth and production performance (Estévez, 2015).

**Effect of rosemary supplement on the reproductive performance of Libyan pigeons**

The effect of rosemary supplements on the reproductive performance and external physical characteristics of eggs are presented in Table 4. Egg weight and incubation period was not significantly affected by the rosemary supplement. However, rosemary supplements at the amounts mentioned in this study lead to deterioration of some reproductive traits of local pigeons.

Egg volume and egg hatchability in treatment groups were lower than in C group (p < 0.05). Egg width and egg surface area tended to be decreased with the rosemary supplement and this decline was significant between T1 and C groups (p < 0.05). Fertility rate, egg length and egg shape index tended to be lower in rosemary supplement groups in comparison with C group, but the difference was not significant (p > 0.05).

Pre-weaning mortality rates tended to be higher in treatment groups when compared to C group, but the difference was not significant (p > 0.05). In contrary to our findings, Şimşek et al. (2015) reported that adding rosemary oil to the ration of quails affected neither the physical characteristics of eggs nor the reproductive performance of birds. In addition, rosemary supplements in the poultry diet improved the physical characteristics of eggs (Abo Ghanima et al., 2020), egg hatchability and fertility (Radwan et al., 2008) or egg fertility without affecting hatchability (Borghei-Rad et al., 2017).

To our knowledge, no study has mentioned a negative effect of rosemary supplement on reproductive performance of birds. In other species, negative effects of rosemary on reproductive perfor-
The results of the effect of rosemary supplementation on the oxidative stress parameters in meat and blood of squabs are presented in Table 5.

Hydroperoxides are the major product of oxidation and can be characterized by a peroxide value. Peroxide value has been long time considered as a good indicator of the degree of meat oxidation which characterizes the primary stage of the oxidation process (Dominguez et al., 2019).

Table 5. The effect of rosemary supplementation on the oxidative stress parameters in meat and blood of squabs

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>Peroxide value (meq.kg⁻¹)</td>
<td>0.60 ± 0.25</td>
<td>0.49 ± 0.10</td>
</tr>
<tr>
<td></td>
<td>TBARS (mg MDA.kg⁻¹)</td>
<td>0.16^a ± 0.01</td>
<td>0.16^a ± 0.01</td>
</tr>
<tr>
<td>Blood</td>
<td>TBARS (mg MDA.l⁻¹)</td>
<td>1.66^a ± 0.02</td>
<td>0.83^ab ± 0.03</td>
</tr>
</tbody>
</table>

^a,b Means with different superscripts in the same row differ significantly (p < 0.05).
be lower in the blood of T1 squab group compared to control, but the difference was not significant (p > 0.05). MDA is one of the final products of lipid oxidation in the cells and its quantity is used as a parameter of oxidative stress (Tsikas, 2017).

In contrary to our results, Dal Bosco et al. (2005) did not find a significant difference in fresh meat MDA concentration between squabs consumed rosemary supplemented diet and the control group.

However, the rosemary supplement decreased MDA concentration in meat after 90 days of freezing. MDA concentration has been decreased in broiler meat (Yesilbag et al., 2011; Ghozlan et al., 2017) or in quail blood and meat (Cetin et al., 2017) after receiving a rosemary-supplemented diet.

In addition, Botsoglou et al. (2007) reported that the oxidative status in turkey meat has been improved by the consumption of a rosemary-supplemented diet. Lower levels of MDA revealed slowness or inhibition of lipid oxidation as a result of improvement of oxidation status in treated birds. Rosemary is rich in phenolic compounds, which can inhibit the free radical formation and hence lipid oxidation (Yesilbag et al., 2011).

CONCLUSION

The addition of rosemary leave powder to the pigeon’s diet caused two different responses: 1) Improvement of productive performance and oxidative status in pigeons, 2) deterioration in some of the reproductive traits. Investigating the effect of rosemary supplement for more than one breeding cycle is recommended before making a final conclusion.

AUTHOR CONTRIBUTIONS

Conceptualization: Akraim, F.
Methodology: Akraim, F., Bellail, A. A.
Investigation: Akraim, F., Alfakhri, M. Y. M., Bellail, A. A.
Data curation: Alfakhri, M. Y. M., Bellail, A. A.
Writing-original draft preparation: Akraim, F.
Writing-review and editing: Akraim, F., Alfakhri, M. Y. M.
Project administration: Akraim, F.
All authors have read and agreed to the published version of the manuscript.

INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES


