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PRODUCTIVE AND PHYSIOLOGICAL RESPONSES OF LAYING HENS FED DIETS SUPPLEMENTED WITH OLIVE LEAF, DATE PALM POLLEN AND ELDERFLOWER POWDERS UNDER SUMMER HEAT STRESS

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Abstract. *Heat stress is a major constraint on egg production in hot climates. This study compared the effects of three plant-derived dietary additives, olive leaf powder, date palm pollen powder and elderflower powder, on productive performance, blood biochemistry, haematology and antioxidant status of laying hens reared under summer heat stress. Eighty Lohmann Brown laying hens aged 26 weeks were allocated to four dietary treatments (five replicate cages of four hens each) for eight weeks (July–August): a basal diet without additives (T), or the basal diet supplemented with 500 mg kg^{-1} of olive leaf powder (T1), date palm pollen powder (T2) or elderflower powder (T3). Date palm pollen (T2) gave the highest egg number and egg weight and the lowest feed intake ($P \leq 0.05$), together with the highest serum superoxide dismutase, catalase and glutathione peroxidase activities and the lowest malondialdehyde concentration. Olive leaf powder (T1) produced the lowest serum glucose and triglyceride concentrations, and both T1 and T3 reduced serum cholesterol relative to the control ($P \leq 0.05$). Elderflower powder (T3) gave the highest haemoglobin concentration and packed cell volume. All supplemented groups had higher total protein and globulin than the control. Date palm pollen at 500 mg kg^{-1} diet is therefore the most effective of the three additives for sustaining egg production and antioxidant status of laying hens in hot summers, while olive leaf and elderflower powders mainly improve blood lipid and haematological profiles.*

Keywords: *laying hens; heat stress; date palm pollen; olive leaf; elderflower; antioxidant enzymes*

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1. INTRODUCTION

Plant-derived feed additives such as herbal powders are increasingly used to improve poultry productivity because they can enhance nutrient metabolism and absorption [1]. Date palm (*Phoenix dactylifera* L.) pollen is a nutrient-dense material that contains essential and non-essential amino acids, fatty acids, proteins, carbohydrates, minerals and antioxidant compounds [2]. It also contains compounds with oestrogen-like structures that can stimulate ovarian activity, egg production and the length of the laying period [3], through effects on follicle-stimulating hormone (FSH) and luteinising hormone (LH) [4]. Its antioxidant content may further reduce oxidative damage and improve health, immunity and productivity of poultry [5].

Olive (*Olea europaea* L.) leaf powder is a promising feed additive because of its phenolic antioxidants, mainly oleuropein and hydroxytyrosol [6]. Olive leaves have anti-inflammatory, glucose-lowering, cholesterol-lowering and antioxidant properties and can increase blood protein concentrations [7,8]. Elderflower (*Sambucus nigra* L.) is a medicinal plant rich in antioxidant compounds, protein and unsaturated fatty acids [9], and can protect cells against oxidative damage caused by heat stress [10].

Heat stress is one of the main factors that reduce the economic efficiency of the poultry industry, so practical strategies to mitigate its effects are of great importance. The thermoneutral zone of poultry, within which birds maintain normal physiological function and productive performance without additional energy expenditure for thermoregulation, is approximately 18–22 °C [11]. Above this range, mitochondrial function is disturbed and the production of free radicals increases [12]. The resulting oxidative stress increases hepatic activity and alters the activity of antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GPX) and catalase (CAT) [13].

Dietary elderflower and elderberry can alleviate heat stress in poultry because of their flavonoids, anthocyanins and other phenolic compounds, which support the endogenous antioxidant system, improve immune responses and help maintain physiological and productive performance at high ambient temperatures [14]. Olive leaf powder or extract has been reported to improve physiological and productive performance of heat-stressed birds, mainly by enhancing SOD, CAT and GPX activities and reducing excessive free-radical production [15]. Date palm pollen, rich in flavonoids, phenolics, amino acids, fatty acids and vitamins, can likewise reduce heat-induced oxidative stress [16].

Few studies have compared these three additives directly under the same heat-stress conditions in laying hens. The aim of this study was therefore to compare the effects of olive leaf powder, date palm pollen powder and elderflower powder on productive performance, oxidative stress indicators and selected physiological traits of laying hens exposed to summer heat stress.

2. MATERIALS AND METHODS

2.1. Birds, diets and experimental design

The experiment was carried out on a laying-hen farm in Babylon Governorate, Iraq, for eight weeks during July and August. Eighty Lohmann Brown laying hens aged 26 weeks were

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randomly allocated to four dietary treatments of 20 hens each; each treatment comprised five replicate cages of four hens (4 treatments × 5 replicates × 4 hens). The control group (T) received the basal diet without additives; the other groups received the basal diet supplemented with 500 mg kg^{-1} of olive leaf powder (T1), date palm pollen powder (T2) or elderflower powder (T3). The composition of the basal diet is given in Table 1; the chemical composition of feed ingredients was calculated according to the NRC [17].

Table 1. Ingredient and calculated chemical composition of the basal diet.

Ingredient	Inclusion (%)
Maize	37.5
Wheat	28.5
Soybean meal	16.0
Protein concentrate (40% CP)	10.0
Calcium carbonate	7.7
Sodium chloride	0.3
Total	**100**
Calculated composition	
Crude protein (%)	17.75
Metabolisable energy (kcal kg^{-1})	2759
Energy-to-protein ratio	155
Lysine (%)	0.86
Methionine (%)	0.41
Calcium (%)	3.60
Available phosphorus (%)	0.44

2.2. Housing and management

A photoperiod of 16 h light per day was provided, and the house temperature during the experiment was about 35 °C. Hens were housed in 20 cages (60 × 65 × 65 cm; four hens per cage), five cages per treatment, and each cage was the experimental unit. Egg number and egg weight were recorded daily, and feed intake was recorded weekly throughout the experiment. Egg production is expressed as the mean number of eggs per replicate cage.

2.3. Blood sampling and analyses

Blood samples were collected at the end of the experiment. Whole blood was used to determine haemoglobin (Hb) concentration and packed cell volume (PCV). Serum was obtained by centrifugation at 3000 rpm and used to determine glucose, cholesterol, triglycerides (TG), total protein, albumin and globulin, and the activities of SOD, CAT and GPX and the concentration of malondialdehyde (MDA).

2.4. Statistical analysis

Data were analysed by one-way analysis of variance in a completely randomised design using SPSS version 11.5 [18]. Differences between means were tested with Duncan's multiple range test and considered significant at $P \leq 0.05$. Results are presented as mean ± standard error.

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3. RESULTS

3.1. Blood biochemistry and haematology

Table 2 shows that all supplemented groups differed significantly from the control ($P \leq 0.05$). Serum glucose was lowest in T1 (169 mg dl^{-1}) and highest in the control (187 mg dl^{-1}). Serum cholesterol was reduced in all supplemented groups, most strongly in T1 and T3 (160 and 159 mg dl^{-1}) compared with 220 mg dl^{-1} in the control. Triglycerides were highest in the control and lowest in T1. Date palm pollen (T2) gave the highest total protein, albumin and globulin, whereas elderflower (T3) gave the highest Hb and PCV.

Table 2. Effect of olive leaf, date palm pollen and elderflower powders on blood biochemical and haematological traits of laying hens under heat stress (mean ± SE).

Group	Glucose (mg dl^{-1})	Cholesterol (mg dl^{-1})	Total protein (g dl^{-1})	Albumin (g dl^{-1})	Globulin (g dl^{-1})	Hb (g dl^{-1})	PCV (%)	TG (mg dl^{-1})
T	187 ± 4.2^{a}	220 ± 4.1^{a}	2.7 ± 0.12^{c}	1.4 ± 0.11^{b}	0.9 ± 0.12^{d}	11.2 ± 0.90^{d}	32.2 ± 1.63^{d}	95 ± 2.20^{a}
T1	169 ± 5.1^{d}	160 ± 2.2^{c}	3.2 ± 1.12^{b}	1.5 ± 0.80^{b}	1.3 ± 0.70^{c}	11.5 ± 0.69^{c}	33.3 ± 2.30^{c}	63 ± 2.04^{d}
T2	173 ± 3.2^{c}	173 ± 3.5^{b}	3.5 ± 1.01^{a}	1.8 ± 0.83^{a}	1.9 ± 0.40^{a}	11.9 ± 0.82^{b}	33.6 ± 2.21^{b}	67 ± 2.30^{c}
T3	178 ± 4.2^{b}	159 ± 1.9^{c}	3.3 ± 1.03^{b}	1.6 ± 0.80^{b}	1.6 ± 0.30^{b}	12.03 ± 1.07^{a}	37.9 ± 1.78^{a}	70 ± 0.90^{b}

T: control; T1: olive leaf powder; T2: date palm pollen powder; T3: elderflower powder (500 mg kg^{-1} diet). Means in the same column with different superscript letters differ significantly ($P \leq 0.05$). Hb: haemoglobin; PCV: packed cell volume; TG: triglycerides.

3.2. Productive performance

Date palm pollen (T2) significantly improved productive performance compared with all other groups ($P \leq 0.05$), with the highest egg number and egg weight and the lowest feed intake (Table 3). Olive leaf (T1) and elderflower (T3) also increased egg number relative to the control.

Table 3. Effect of olive leaf, date palm pollen and elderflower powders on egg number, egg weight and feed intake of laying hens under heat stress (mean ± SE).

Group	Egg number (eggs $cage^{-1}$)	Egg weight (g)	Feed intake (g hen^{-1} day^{-1})
T	12.08 ± 3.20^{c}	55.90 ± 1.23^{c}	156.0 ± 0.30^{a}
T1	14.20 ± 0.90^{b}	57.02 ± 1.90^{b}	154.0 ± 0.90^{c}
T2	17.03 ± 1.30^{a}	65.03 ± 2.02^{a}	153.4 ± 2.01^{d}
T3	13.90 ± 0.80^{b}	56.20 ± 2.30^{c}	155.0 ± 1.20^{b}

Treatments as in Table 2. Means in the same column with different superscript letters differ significantly ($P \leq 0.05$).

3.3. Antioxidant status

Date palm pollen (T2) gave the highest SOD, CAT and GPX activities and the lowest MDA concentration ($P \leq 0.05$; Table 4). Olive leaf (T1) and elderflower (T3) also improved all four indicators compared with the control, with T1 ranking second.

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Table 4. Effect of olive leaf, date palm pollen and elderflower powders on serum antioxidant indicators of laying hens under heat stress (mean ± SE).

Group	SOD (IU mL^{-1})	MDA	CAT (IU L^{-1})	GPX (IU L^{-1})
T	4.20 ± 0.20^{c}	8.20 ± 0.31^{a}	150 ± 1.03^{d}	186 ± 0.01^{d}
T1	6.99 ± 0.01^{b}	3.20 ± 0.32^{c}	230 ± 0.02^{b}	230 ± 0.10^{b}
T2	8.03 ± 0.03^{a}	2.60 ± 0.21^{d}	240 ± 0.40^{a}	237 ± 0.01^{a}
T3	6.80 ± 0.03^{b}	4.10 ± 0.04^{b}	222 ± 0.03^{c}	220 ± 0.06^{c}

Treatments as in Table 2. SOD: superoxide dismutase; MDA: malondialdehyde; CAT: catalase; GPX: glutathione peroxidase. Means in the same column with different superscript letters differ significantly ($P \leq 0.05$).

4. DISCUSSION

The lower serum glucose of hens fed olive leaf powder agrees with an earlier report [7]. Oleuropein, the main bioactive compound of olive leaves, stimulates insulin secretion, enhances cellular glucose uptake and promotes hepatic glycogen synthesis [19,20]. The reduction in serum cholesterol in the supplemented groups is consistent with previous studies [14,21], and reflects the lipid-lowering activity of olive leaf phenolics and elderflower flavonoids.

The higher total protein, albumin and globulin of hens fed date palm pollen agree with [22] and can be attributed to its high content of protein, essential amino acids, vitamins, minerals and bioactive compounds such as flavonoids, phenolics and sterols, which may stimulate hepatic protein synthesis [23]. The highest Hb and PCV in the elderflower group may be explained by its relatively high content of minerals such as Ca, Mg, Fe, Cu and Mn and of vitamin C, which support haemoglobin synthesis [24]. All additives lowered serum triglycerides compared with the control, in line with the triglyceride-lowering effect of plant bioactive compounds [25].

The superior egg production of hens fed date palm pollen agrees with [3]. Date palm pollen contains oestrogenic compounds such as oestradiol and oestrone that stimulate reproductive hormone secretion [26], together with amino acids, vitamins, minerals, phenolics and flavonoids that improve the physiological status of the birds, the efficiency of nutrient utilisation, ovarian activity and egg production [16].

The best antioxidant profile was also found with date palm pollen, which is rich in phenolics, flavonoids, vitamins and essential minerals that reduce oxidative stress and support physiological function [27]. Olive leaf and elderflower powders also improved antioxidant indicators, owing to their high content of antioxidant compounds [28]. Olive leaf phenolics reduce lipid peroxidation and hence MDA, the key indicator of oxidative stress [29], and elderflower phenolics and flavonoids scavenge free radicals, enhance antioxidant enzyme activity and protect cell structures under heat stress [14,30].

5. CONCLUSIONS

Under summer heat stress, all three plant additives improved the performance and physiological status of laying hens compared with the control, but to different extents. Date palm pollen powder at 500 mg kg^{-1} diet was the most effective additive, increasing egg number and egg weight, reducing feed intake and improving antioxidant enzyme activities.

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Olive leaf powder mainly improved serum glucose and lipid profiles, and elderflower powder improved haematological traits. Further studies should test combinations of these additives to evaluate their synergistic effects on heat-stressed laying hens.

AUTHOR CONTRIBUTIONS

Suhad H. I. Al-Shammary: Conceptualization, Methodology, Investigation, Writing – original draft. Hadeel A. Almamoory: Investigation, Formal analysis, Writing – review & editing. All authors have read and approved the final manuscript.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The study protocol was reviewed and approved by the Ethics Committee of Al-Mussaib Technical College, Al-Furat Al-Awsat Technical University (Approval No. 102/ALMS, dated 12 November 2026). The hens were kept under commercial husbandry conditions, and the only invasive procedure was a single blood sample collected from each sampled hen at the end of the trial.

USE OF GENERATIVE AI

Generative AI was used only for language editing of the manuscript; the authors take full responsibility for its content.

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