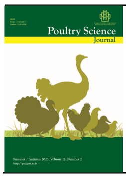

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Effect of Dietary Purslane (*Portulaca oleracea* L.) and Garden Cress (*Lepidium sativum*) Seeds on Productive Performance, Yolk Fatty Acids Profile, Serum Lipoproteins and Egg Quality in Japanese Quails

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Abstract
This experiment was carried out to investigate the effects of dietary inclusion of purslane and garden cress seeds on productive performance, yolk fatty acids profile, blood biochemical parameters and egg quality in Japanese quails. A total of 150 one-day-old quail chicks were randomly assigned to five experimental groups with six replicates including a control diet (without inclusion of remedies) and the diets containing 50 or 100 g/kg either purslane seeds or garden cress for 84 days. egardless of the inclusion level, dietary purslane and garden cress seeds decreased egg mass production compared to the control group ($P < 0.05$). All experimental treatments reduced yolk cholesterol compared with the control birds, where the diets containing 100 g/kg purslane seed or garden cress were more effective. Feeding birds with a diet containing 100 g/kg purslane seed reduced yolk percentage compared to the other diets ($P < 0.05$). Birds fed with the diet containing 100 g/kg garden cress showed an increased yolk concentration of mono- (MUFA) and poly-unsaturated fatty acids (PUFA) and a decreased omega-6 fatty acids as well as omega-6 to omega-3 ratio (n-6/n-3; $P < 0.05$). The diet containing 100 g/kg purslane seed increased yolk concentration of PUFA and omega-6 fatty acids ($P < 0.05$). The birds fed diet fortified with 50 g/kg garden cress decreased PUFA concentration of yolk ($P < 0.05$). A greater omega-3 fatty acids concentration of yolk was found in the birds maintained on the diet containing 100 g/kg garden cress while a lesser level was exhibited in those fed on the diet with 100 mg/kg of the same additive. Serum triglyceride concentration was increased in the birds receiving the diet with 100 g/kg purslane ($P < 0.05$). The diets containing garden cress increased the serum activity of the alanine aminotransferase (ALT) enzyme ($P < 0.05$). Shell ratio, egg-specific weight and yolk ratio were significantly reduced in the birds fed on the diet with 50 g/kg garden cress ($P < 0.05$). On the contrary, the inclusion of 100 g/kg purslane in the diet decreased eggshell weight, egg-specific weight, shape index, shell thickness and yolk ratio ($P < 0.05$). Dietary purslane seeds may improve egg quality through a reduced yolk concentration of cholesterol in quail eggs. An improved fatty acid profile, an elevated omega-3 fatty acid, and a healthier n-6/n-3 ratio was observed, particularly with the diet containing 100 g/kg garden cress.

Introduction

Recent studies have shown that the fatty acid composition of food is an effective factor in the occurrence and prevention of cardiovascular diseases in human cases (Simopoulos, 1991). The role of omega-3 fatty acids has been frequently reported in preventing the growth of breast and prostate cancer (Hanson *et al.*, 2020), reducing the lag time in immune responses (Gutiérrez *et al.*, 2019), decreasing the incidence of arteriosclerosis (Sang *et al.*, 2021)

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and the risk of death due to coronary heart disease (Drenjančević and Pitha, 2022).

Poultry egg is a common and well-defined food source in human communities worldwide. However, the fat fraction in egg yolks may exceed 20 percent while its fatty acid composition varies greatly (Zita *et al*., 2022). Currently, the consumption of egg yolk supplemented with omega-3 fatty acids is considered an adoptable alternative to enhance the intake of these essential fatty acids. A number of previous studies howed that feeding birds with diets rich in omega-3 fatty acids can increase egg yolk content of omega-3 fatty acids (Betancourt and Díaz, 2009). Supplementation of the regular poultry diets with the sea and herbal natural sources of omega-3 fatty acids mostly increases the omega-3 contents in poultry products (Cherian and Quezada, 2016).

Purslane, *Portulaca oleracea*, is an annual herbaceous plant with a fleshy, red stem and thick, opposite, juicy green leaves, small yellow or white flowers, and tiny black eggs exerting many medicinal properties (Sultana and Rahman, 2013). This plant contains significant amounts of lignin, flavonoids and natural antioxidants, omega-3 fatty acids, beta-carotene, vitamins A, B, C, E, and minerals such as potassium, calcium, magnesium, iron, among many other beneficial bioactive constituents (Lim and Quah, 2007). It was reported that purslane contains 6.8-19 mg of oleic acid, 19 mg of MUFA, 28.2-54.8 mg of linoleic acid and 26.8- 68.8 mg of linolenic acid per gram (Uddin *et al*., 2014). In a study, feeding chickens with diets containing ingredients rich in alpha-linolenic acid, such as purslane increased egg yolk concentration of the same fatty acid (Van Elswyk, 1997).

Garden cress (*Lepidium sativum)* as an herbal remedy belonging to the genus Chetrian demonstrates significant medicinal properties. It was shown that garden cress lowers blood concentrations of triglycerides and cholesterol (Diwakar *et al*., 2010). Phytochemical study of the plant revealed that it contains sterol, saponin, glycosinolate, sulfur-glycosides, indole, terpenoids, isothiocyanate and a spectrum of secondary metabolites including phenolic compounds such as tannins and flavonoids (Dannehl *et al*., 2012). It was reported that garden cress has anti-inflammatory, anti-bacterial and anti-parasitic properties (Agarwal and Verma, 2011). It was also shown that garden cress increased blood concentration of HDL and decreased LDL in mice and humans (Chauhan *et al*., 2012). Al-Taee (2013) reported that the inclusion of garden cress seeds at 10 to 15 g/kg into a diet improved the feed conversion ratio and egg production in laying hens. Dietary inclusion of the same remedy at 15 g/kg was also shown to increase lipid excretion by reducing lipid absorption, ultimately leading to a leaner carcass in poultry (Abdel Atti *et al*., 2013). It was also shown that the supplementation of chicks by 1% cress seeds could enhance the behavior, growth performance and economic efficiency of broilers (Hassan *et al*., 2019).

Therefore, in the present study, we investigated the effects of dietary inclusion of purslane and garden cress seeds on productive performance, yolk fatty acids profile, serum lipoproteins and egg quality and in Japanese quails**.**

Materials and Methods

Flock management and experimental treatments

All stages of the experimentation period and laboratory work were carried out in the Animal Science Department, Lorestan University research farm and laboratory. The chicks were reared on paper-furnished floor pens for 42 days and then transferred to cages. A total number of 150 Japanese quails were used in a completely randomized design (CRD) with 6 replicates of 5 birds each in battery cages to evaluate the effects of 5 dietary treatments including a control diet, a diet containing 50 g/kg purslane (Pur.50), a diet containing 100 g/kg purslane (Pur.100), a diet containing 50 g/kg garden cress (GC50) and a diet containing 100 g/kg garden cress (GC100). Egg production, egg quality traits, yolk fatty acids profile and certain blood biochemistry variables were measured as response parameters. Quails were kept under the same conditions as the pre-experimental phase at the ambient temperature of 27-28 °C where water and feeding spaces were provided adequately for 12 weeks. Biosecurity standards were warranted during the experimentation period. Experimental diets were formulated based on the nutrient requirements of Japanese quail (NRC, 1994; Table 1).

Analysis of purslane and garden cress seeds

Chemical analysis and fatty acids profile of purslane and garden cress has been performed on 3 random samples of the bulks of the remedies provided at the initiation of the experiment and the results are displayed in Tables 2 and 3, respectively.

Production performance

Birds were weighed weekly at the beginning and the close of each week. Egg production was recorded daily. Records of the feed intake (FI, g) were taken every week by subtraction of the leftover feed weight from the feed provided in each week. Egg mass was calculated using all eggs collected from each treatment group at a 14-days interval during the experiment. Feed conversion ratio (FCR) was calculated as; (grams of consumed feed/egg mass (g of egg g of diet^{-1}).

Table 1. Ingredients and nutrient composition of diets[1]

Ingredients (%)	Control	Pur. 50	Pur. 100	GC50	GC100
Yellow corn	55.42	52.25	48.19	52.54	48.33
Soybean meal (44% CP)	35.07	34.53	33.48	34.48	33.20
Fish meal	3	3	3	3	3
Corn oil	0.16	0.17	0.48	0.18	0.51
Purslane seeds[1]	-	5	10	-	-
Garden cress seeds[1]	-	-	-	5	10
Wheat bran	1.1	-	-	-	-
Common Salt	0.3	0.3	0.3	0.3	0.3
Vitamin premix[2]	0.25	0.25	0.25	0.25	0.25
Mineral premix[2]	0.25	0.25	0.25	0.25	0.25
Dicalcium phosphate	4.45	4.25	4.05	4.00	4.16
	Nutrient composition (calculated)				
ME (Kcal/ kg)	2996	2987	3005	3007	2995
Crude protein (%)	22.23	22.43	22.49	22.67	22.82
Ether extract	5.77	5.78	5.78	5.78	5.78
Crude fiber	3.25	3.51	3.87	4.04	4.31
Ash	3.97	3.95	3.92	3.98	3.87
Ca	1.07	1.12	1.18	1.23	1.29
Total P	0.87	0.86	0.86	0.85	0.84
Available P	0.57	0.56	0.55	0.55	0.54
L-Lysine	1.22	1.21	1.20	1.20	1.19
DL-Methionine	0.65	0.65	0.66	0.67	0.68

[1] Pur.50; a diet containing 50 g/kg purslane, Pur.100; a diet containing 100 g/kg purslane seed, GC50; a diet containing 50 g/kg garden cress and GC100; diet containing 100 g/kg garden cress seed.
[2]Vitamin A, 440,000 international units; Vitamin D3, 160,000 international units; Vitamin E, 1,500 international units; Vitamin K3, 128 mg; Vitamin B1, 74 mg; Vitamin B2, 260 mg; Vitamin B3, 490 mg; Vitamin B5, 1,600 mg; Vitamin B6, 120mg; Vitamin B9, 60mg; Vitamin B12, 0.6mg; Vitamin H2, 4mg; Anti-oxidant, 250mg; Choline chloride, 20,000mg.
[2]Manganese, 4,800 mg; Zinc, 4,400 mg; Copper, 650 mg; Selenium, 12 mg; Iodine, 48 mg; Iron, 2,000 mg.

Table 2. Analysis of purslane and garden cress (g/100 g)

	DM	CP	EE	Ash	ME (Kcal/g)	CF
Purslane	87.00	16,30	5.90	5.80	38.56	15.80
Garden cress	94.90	22.40	19.90	6.30	44.64	28.10

DM: Dry Matter, CP: Crude Protein, EE: Ether Extract, ME: Metabolizable Energy, CF: Crude Fiber

Table 3. Fatty acid concentration of Purslane and garden cress samples (mg/g sample)

Fatty acid	garden cress	Purslane
Myristic, C14:0	0.000	0.039
Palmitic, C16:0	12.621	6.387
Palmitoleic, C16:1	0.369	0.066
Margaric, C17:0	0.039	0.019
Heptadecenoic, C17:1	0.031	0.000
Stearic, C18:0	2.965	1.391
Oleic, C18:1 (n-9)	38.084	8.928
Linoleic, C18:2 (n-6)	16.819	15.679
α-linolenic, C18:3 (n-3)	42.171	1.723
Eicosenoic, C20:1	0.450	0.155
Eicosadienoic, C20:2	17.862	0.167
Arachidonic, C20:4 (n-6)	0.681	0.000
Gama-linolenic, C18:3 (n-6)	38.084	0.117

Measurement of egg quality attributes

Certain indicethe eggs' exterior and interior parts were measured weekly using 4 eggs per replicate pen according to the procedure of Abd El-Hack *et al*. (2017). In brief, average egg weights were measured using a 0.01g precision digital scale. Egg length and width were measured before breaking using a digital caliper. After that, the eggs were broken on a clean glass plate, yolks were cleaned from the adhering albumens and interior and exterior egg quality features were assayed. The albumen weight was determined by; [(whole egg weight) – (yolk weight + albumen weight)]. Egg exterior dimensions were measured using a caliper. The egg shape index was calculated as the ratio of average egg width to the average length; the yolk index is the ratio of yolk height to its average diameter (Awosanya and Joseph, 1998). The Haugh unit was calculated using the formula Eisen et al. (1962) described as: HU = 100 log (H + 7.57 − 1.7 EW0.37, where H represents the albumen height and EW stands for the egg weight). Shell thickness was measured by a micrometer by averaging the values taken at four points of the eggshell (air cell, equator at two points, and sharp end) (Abd El-Hack *et al*., 2017).

Total lipid and fatty acid composition

About 2g of each yolk sample (7 samples per treatment) as well as three samples of the diets, was undergone lipid extraction using chloroform: methanol (2:1) according to the method of Folch *et al*. (1956). Methanolic HCl was used for the preparation of fatty acid methyl esters. An internal standard (23:0) (Matreya, PA) was applied for fatty acid quantification. Fatty acids analysis was performed with an Agilent 6890 gas chromatograph (Agilent Technologies, CA) equipped with an auto sampler, flame-ionization detector, and fused-silica capillary column, 30 m × 0.25 mm × 0.2 μm film thickness (Supelco, PA). Each sample (1 μL) was injected with helium as a carrier gas into the column programmed for enhanced oven temperatures (the initial temperature of 110 °C was held for 0.5 min, then increased by 20 °C/ min to 190 °C, held for 7 min, and then raised at 5 °C/ min to 210 °C and kept for 8 min). Inlet and detector temperatures were both 250 °C. Peak areas and fatty acid percentages were calculated using Agilent Chem Station software (Agilent Technologies, CA). Fatty acid methyl esters were partitioned by comparison with retention times of authentic standards (Matreya, PA) and were expressed as percentages of total fatty acid methyl esters or as mg. egg.

Statistical analysis

The collected data were undergone 1-way analysis of variance through the General Linear Model procedure of the Statistical Analysis Software of SAS Institute (2003) in a completely randomized design. The means were differentiated using Tukey test. In all analyses, the significance was declared at 5 percent.

Results

No significant difference was observed in feed intake (FI) and feed conversion ratio (FCR) among the birds grown on different dietary treatments. However, dietary purslane and garden cress, regardless of the inclusion level, decreased ($P < 0.05$) egg mass production compared to the control group, where quails fed on the purslane-added diet (50 g/kg) showed a lower egg mass production (Table 4).

A lower yolk cholesterol was recorded in the birds receiving the diet containing purslane (100 g/kg) and garden cress (100 g/kg). Feeding birds with the diet containing purslane (50 and 100 g/kg) decreased yolk fat percentage fat compared with those fed the diet containing garden cress (50 g/kg) (Table 5).

Table 4. Means of average daily egg mass production (g/b/d), average daily feed intake (g/b/d) and feed conversion ratio (g: g) in Japanese quails received diets containing different levels of purslane and garden cress.

Treatments	FI	FCR	Egg Mass
Control	28.683	3.384	8.472[a]
50 g/kg purslane	27.704	3.518	7.904[b]
100 g/kg purslane	28.203	3.516	8.026[b]
50 g/kg garden cress	27.065	3.372	8.026[b]
100 g/kg garden cress	26.918	3.222	8.363[ab]
SEM	1.871	0.250	0.341
P-value	0.449	0.359	0.035

[a-b]The means within the same column with at least one common letter, do not have significant difference ($P > 0.05$).

Table 5. Yolk fat and cholesterol concentrations (mg/g) in Japanese quails fed diets containing different levels of purslane and garden cress

Treatment	Cholesterol	Fat
Control	15.930 [a]	62.350[ab]
50 g/kg purslane	12.907 [ab]	64.037[a]
100 g/kg purslane	11.008 [b]	61.449 [b]
50 g/kg garden cress	12.597 [ab]	63.396[ab]
100 g/kg garden cress	11.279 [b]	63.510 [ab]
SEM	1.731	0.889
P-value	0.038	0.034

[a-b] The means within the same column with at least one common letter, do not have significant difference ($P > 0.05$).

Dietary inclusion of purslane and garden cress showed no effect on yolk concentration of saturated fatty acids ($P > 0.05$). Mean serum MUFA concentration was greater in the birds fed on the diet supplemented with either purslane (50 g/kg) or garden cress (100 g/kg) by 7.86 and 9.46 percent, respectively, compared with the control group. Inclusion of purslane (100 g/kg) in the diet increased egg yolk concentration of PUFA, decreased omega-3, reduced omega-6 fatty acids and increased the ratio of omega-6 to omega-3 fatty acids by 38.78, 38.70, 27.13 and 18.65, respectively, compared to the control birds ($P < 0.05$) (Table 6).

Table 6. Fatty acids profile (mg/g of total fatty acids) in Japanese quails received different levels of purslane and garden cress

Treatments	Fatty acid profile					
	SFA	MUFA	PUFA	n-3	n-6	N6:N3
control	106.922	123.519[ab]	45.661[b]	4.450[bc]	58.919[a]	13.319[a]
50 g/kg purslane	96.804	133.226[a]	52.626[ab]	3.430[bc]	49.195[ab]	14.398[a]
100 g/kg purslane	83.096	106.395[b]	63.369[a]	2.728[c]	42.933[b]	15.803[a]
50 g/kg garden cress	90.242	122.824[ab]	48.552[b]	5.693[ab]	42.452[b]	7.503[b]
100 g/kg garden cress	101.204	135.201[a]	46.843[b]	7.716[a]	38.450[b]	5.084[b]
SEM	9.962	2.104	2.510	0.641	1.232	1.394
P-value	0.099	0.021	0.017	0.001	0.003	0.001

[a-c] The means within the same column with at least one common letter, do not have significant difference ($P > 0.05$).

A higher serum triglyceride concentration was observed in the birds fed purslane (100 g/kg) compared with the control group ($P < 0.05$). Feeding quails with diets containing purslane (50 g/kg) and garden cress (50 g/kg) decreased serum concentration of LDL ($P < 0.05$) and increased serum activity of AST and ALT. Serum concentrations of glucose, cholesterol, HDL and ALK levels were similar among the birds maintained on different dietary treatments ($P < 0.05$) (Table 7).

Table 7. Means of blood biochemical parameters and hepatic enzymes activity in Japanese quails received different levels of purslane and garden cress seeds

Treatments	blood biochemical parameters							
	FBS (mg/dL)	TG (mg/dL)	CHOL (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	AST (u/L)	ALT (u/L)	ALK (u/L)
control	292.50	537.30[b]	206.83	250.50	112.83[a]	157.83[b]	147.83[b]	1429.30
50 g/kg purslane	269.00	593.30[b]	151.83	225.50	71.67[b]	204.17[ab]	209.00[ab]	1525.20
100 g/kgt purslane	279.00	786.70[a]	187.50	279.00	83.17[b]	176.83[ab]	156.33[ab]	1235.50
50 g/kg garden cress	274.33	772.0[a]	194.17	314.67	75.50[b]	246.00[a]	219.83[a]	1478.00
100 g/kg garden cress	263.67	530.50[b]	202.00	295.83	91.83[ab]	190.17[ab]	152.00[b]	1636.00
SEM	28.24	57.00	47.34	80.51	14.53	42.90	38.56	298.70
P-value	0.472	0.014	0.308	0.348	0.000	0.019	0.005	0.244

[a-c] The means within the same column with at least one common letter, do not have significant difference ($P > 0.05$).

Table 8. Egg quality parameters and indices in Japanese quails received the experimental diets.

Treatments	Control	50 g/kg purslane	100 g/kg purslane	50 g/kg garden cress	100 g/kg garden cress	*SEM*	P-value
Egg weight (g)	11.630	11.536	11.337	11.264	11.718	0.542	0.564
Albumen height (mm)	6.320	6.421	14.150	5.676	5.386	9.829	0.509
Yolk width (mm)	24.661[a]	24.677[a]	25.198[a]	24.550[a]	23.329[b]	0.582	0.000
Yolk height (mm)	13.309[a]	13.296[a]	12.040[b]	11.958[b]	12.468[b]	0.393	0.000
Shape index	78.988[a]	78.158[a]	78.530[a]	73.763[b]	78.477[a]	1.362	0.000
Chalaziferous width (mm)	32.178	33.210	31.892	32.160	33.017	2.008	0.732
Albumen length (mm)	72.264	73.758	71.745	71.767	70.147	4.156	0.679
Albumen width (mm)	52.983	50.071	49.478	51.043	51.802	2.841	0.251
Shell thickness (mm)	0.331[a]	0.273[b]	0.236[c]	0.228[c]	0.250[bc]	0.016	0.000
Eggshell weight (g)	1.016[a]	0.940[ab]	0.894[b]	0.870[b]	0.888[b]	0.057	0.001
Eggshell area (mm)	25.080	24.936	24.612	24.486	25.228	0.882	0.565
Shell ratio(percent)	8.769[a]	8.154[ab]	7.880[b]	7.737[b]	7.566[b]	0.499	0.003
Yolk ratio (g:g)	53.983[a]	53.884[a]	47.777[b]	48.737[b]	53.451[a]	1.461	0.000
Haugh unit	98.55	99.070	107.670	95.770	94.100	15.820	0.627
Egg-specific gravity (g/cm^3)	1.080[a]	1.076[ab]	1.075[b]	1.074[b]	1.073[b]	0.003	0.003

[a-c] The means within the same column with at least one common letter, do not have significant difference ($P > 0.05$).

Feeding birds with the purslane and garden cress-added diets significantly reduced eggshell thickness (Table 6). A greater reduction was observed in the birds fed on the garden cress (50 g/kg) containing diet ($P < 0.05$). Shell ratio, egg specific weight, yolk ratio, yolk height, eggshell weight and shape index were significantly reduced by feeding birds with the diet supplementing garden cress (50 g/kg) by 11.77, 0.93, 9.71, 10.14,14.71 and 6.62 percent, respectively, compared with the control group ($P < 0.05$). Inclusion of purslane (100 g/kg) reduced egg shell weight, egg specific weight, shape index, shell thickness, and yolk ratio ($P < 0.05$) by 12.01, 0.46, 0.58, 28.7 and 11.48 percent, respectively, compared with the control group. A significant decrease ($P < 0.05$) in yolk width and egg-specific weight was observed with adding garden cress (100 g/kg). Egg weight, albumen height, albumen width, albumen length, surface of eggshell and Haugh units were not affected by the experimental treatments ($P > 0.05$) (Table 8).

Discussion

The current study showed no change in FI and FCR when purslane and garden cress (GC) were supplemented in quail diets at 50 and 100 g/kg. Evaris *et al*. (2015) and Nobakht (2014) reported an increased daily FI in hens fed on diets containing 2 and 20 percent purslane, respectively, whereas Moazedian and Saemi (2018) found no change in FI when purslane was supplemented up to 2 percent and 25 percent in broiler diets, the results which also confirmed by and Aydin and Dogan (2010). Evaris *et al*. (2015) attributed the differences in FI observed to the self-regulation of FI in young birds at the energy level of the diet. Although some studies have already reported that different n-3 PUFA-rich feed sources for chickens reduced FI and thus egg production rate (Ebeid *et al*., 2008). The lowered palatability of the diet may reveal a reasonable justification due to PUFA oxidation. The marginal reduced FI of the birds in the present study can be attributed to possible anti-nutritional factors in the medicinal plants used. It has been reported that the seeds of GC contain tannin, phytic acid, oxalic acid and cyanogens, which may disrupt the bioavailability of nutrients (Al Hamedan, 2010). In agree with the present research results, Adlband *et al*. (2016) reported that the extract of the GC seed has no effect on FI and FCR in Japanese quails. Regarding egg production, egg mass /quail/day was significantly lower in the Purslane- and garden cress-receiving birds. These results largely depend on the reduction in FI of the chickens receiving the supplemented diets.

In several studies, dietary administration of purslane (Aydin and Dogan, 2010; Nobakht, 2014) or other n-3 PUFA sources (Ahmad *et al*. 2012) have exerted no effect on egg production parameters, as the birds had a positive energy balance that allowed them to maximize their egg production performance. Nevertheless, many other studies showed that the inclusion of PUFA sources such as linseed in the diet or sunflower seed (Aguillon-Paez *et al*., 2020) may positively influence egg production. In the current study, diets containing purslane and garden cress significantly reduced the shell thickness, shell ratio, specific weight, yolk ratio, yolk height, shell weight and shape index of the quail eggs. A recent study by Kartikasari *et al*. (2020) showed an increased yolk color intensity when hens were fed on a diet supplemented with eight percent of *Portulaca oleracea* powder. *Portulaca oleracea* is a plant rich in beta-carotene and xanthophylls that could enhance the yolk's lightness and yellowness without affecting yolk color. Lipid content of diet was shown to be positively correlated with the absorption and deposition of oxycarotenoids which are responsible for egg yolk pigmentation. A possible explanation could lie either in the lower lipid ingestion in the Purslane-fed hens or on the hypotriglyceridaemic effect of this additive due to the receiving dietary n-3 PUFA (Ahmad *et al*., 2012). It is well known that the fatty acids profile of the diet including SFA, MUFA, PUFA, n-3 and n-6 classes is the main determinant in the fatty acid composition of the yolk. Therefore, the ability of hens to transfer the fatty acids into their eggs enables the poultry nutritionist to improve hen egg composition as healthier food for humans. Ebeid *et al*. (2011) showed that meat produced in quails fed with diets enriched with different sources of n-3 PUFA had an improved antioxidant capacity and a lowered lipid peroxidation in the constituting tissues, with no adverse effect on live weight and feed intake of the birds. In our study, the diet containing purslane and garden cress increased PUFA and n-3 fatty acids and decreased the n-3/ n-6 ratio compared with the birds receiving the control treatment. These findings are in line with the results reported by many previous studies (Aydin and Dogan, 2010; Evaris *et al*., 2015; Moazedian and Saemi, 2018) on the dietary administration of *Portulaca oleracea* in laying hens. Aydin and Dugan (2010) included purslane at the 20 g/kg level in a hen diet and found a significant increase in omega-3 fatty acids such as C18:3 and C22:6 in yolk. The ratio of omega-6 to omega-3 in the eggs of the birds fed with the rations containing 10 g/kg or 20 g/kg purslane was significantly lower than in the control birds. Our results disagree with these findings where dietary purslane increased the ratio of omega-6 to omega-3. Also, Zotte and Pranzo (2022) stated that the use of purslane in the diet significantly reduced the percentage of saturated fatty acid in the yolk, while it increased the PUFA content, where both ratios of omega-6 and omega-3 increased significantly compared to the control group. They confirmed the use of purslane to produce eggs enriched with omega-3 when the palatability problem is solved and the energy needs of the birds are solved.

In the present study, purslane-added diets decreased the amount of omega-6 and omega-3 fatty acids but increased the omega-6 to omega-3 ratio and

PUFA, which was in agreement with the results of Zotte and Pranzo (2022). However, the use of garden cress seeds increased the percentage of omega-3, C18:3n3, MUFA, C22:5n6, C22:6n3 and the ratio of omega-6 to omega, so that the best ratio was observed in the treatment of 100 g/ kg GC. Therefore, these results show a potential for using purslane and garden cress as an n-3 PUFA-containing feed ingredient for quails. Yolk cholesterol content was not different among the two feeding groups. Our results agree with those of Moazedian and Saemi (2018) who reported a prominent decrease in yolk cholesterol content in the hens receiving a diet containing 25 percent *Portulaca oleracea* seeds. Other workers found a significant decrease in yolk cholesterol concentration when diets enriched with linseed or olive oil fed to laying hens (Zhang and Kim, 2014). Whereas other researchers did not find a yolk cholesterol lowering effect for these phytogenic products (Mattioli *et al*., 2017; Yalcyn *et al*., 2007). It was suggested that yolk cholesterol content may be modulated by an increased dietary crude fibre level rather than by a greater PUFA content. Considering direct uptake of cholesterol from the circulation into the yolk sac, it may be inferred that an increased dietary PUFA concentration at the expense of the saturated fatty acids can exert a promising outcome in reducing the yolk cholesterol.

Our findings also demonstrate that dietary supplementation of purslane and garden cress seeds positively modifies certain serum biochemical parameters such as reduced LDL and triglycerides in hens. These advantageous effects can be discussed concerning the high antioxidant capacity of their active ingredients. Like many herbal products, these remedies are rich in linoleic acid, a type of omega-6 fatty acid, that may be associated with improvement in several hematological and biochemical parameters in birds (Diwakar *et al*., 2010; Abbas *et al*., 2016; Bardaa *et al*., 2016). A reduced LDL, known as bad cholesterol, may be attributed to the inhibition of the key enzyme involved in regulating cholesterol synthesis, known as HMG-CoA reductase activity (Ciftci *et al*., 2010). Plasma levels of glucose, cholesterol, LDL and alkaline phosphatase levels did not differ between the birds maintained on purslane and garden cress-supplemented diets, the results with those reported by Abbas *et al*. (2016). It was reported that purslane and garden cress derivative constitute, such as oil are rich in mono- and poly phenolic phytochemicals as well as vitamin E, which almost all show a range of antioxidant capabilities (Abbas *et al*., 2016; Al-Sayed *et al*., 2019). Phenolic compounds are well-known natural antioxidants responsible for the high antioxidant activity of most medicinal remedies (Stevenson *et al*. 2007; Al-Sayed *et al*. 2019; Vlaicu and Panaite, 2022).

Conclusion

In conclusion, this study showed that the inclusion of purslane and garden cress seeds in a commercial quail's diet has multiple beneficial effects on eggs where they increased the proportion of PUFA, reduced the n-6/n-3 ratio, LDL and triglycerides content of the eggs.

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