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Effect of plant-based feed additives on egg quality and yolk oxidative stability in laying hens

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Abstract: The study evaluated the effects of garlic, onion, and paprika supplementation on egg quality, yolk oxidative status, and fatty acid composition in ISA Brown laying hens over 56 days. Birds received a control diet or diets supplemented with each additive at 2.5 or 5 g/kg feed. Supplementation did not affect most egg quality traits, but paprika significantly enhanced yolk color, especially at 5 g/kg. Yolk oxidative status improved, with lower malondialdehyde and higher total antioxidant capacity, mainly in paprika and secondarily in onion groups, while the highest total phenolic content was observed in the paprika high group. Total polyunsaturated and omega-6 fatty acids also increased significantly. Overall, paprika showed the strongest beneficial effects.

Introduction

The growing interest in natural alternatives to synthetic additives has increased the use of plant-based compounds in poultry nutrition. Garlic, onion, and paprika contain bioactive compounds such as phenolics, carotenoids, and sulfur-containing substances with antioxidant and antimicrobial properties. These compounds may improve egg quality, enhance yolk oxidative stability, and modify fatty acid composition. Since lipid oxidation reduces both the nutritional value and shelf life of eggs, indicators such as malondialdehyde, total antioxidant capacity, and total phenolic content are commonly evaluated. Therefore, this study examined the effects of garlic, onion, and paprika supplementation on egg quality, antioxidant status, and yolk fatty acid composition in laying hens.

Materials and methods

SA Brown laying hens were used in a 56-day trial to evaluate garlic, onion, and paprika as dietary additives. Seven treatments were applied: control and diets supplemented with each additive at low or high inclusion levels. Each treatment included six replicate cages with two hens per cage. Eggs were collected every 14 days to assess egg quality traits, including egg and shell weight, shell thickness, yolk color, and yolk and albumen pH. Yolk samples were also collected for determination of oxidative status and fatty acid composition. Fatty acids were analyzed by gas chromatography, oxidative parameters spectrophotometrically, and data were analyzed by one-way ANOVA with Tukey's test.

Results and discussions

Dietary supplementation with garlic, onion, and paprika had limited effects on most egg quality traits (Table 2), as egg weight, shell weight, and shell thickness were generally unchanged, indicating no negative impact on egg structural quality. The main quality trait consistently affected was yolk color, which was significantly enhanced in paprika-supplemented groups, especially at the higher inclusion level. Fatty acid analysis showed no significant changes in Σ SFA or Σ MUFA, whereas Σ PUFA and ω 6 fatty acids increased significantly, particularly in the high garlic, onion, and paprika groups (Table 1). Oxidative status was also improved, with lower MDA and higher TAC and TPC values, mainly in paprika and secondarily in onion treatments (Table 3). Overall, paprika showed the strongest beneficial effects on yolk quality and oxidative stability.

Conclusions

Dietary supplementation with garlic, onion, and paprika did not impair egg quality, but improved yolk pigmentation, oxidative stability, and lipid composition. Paprika, especially at the higher inclusion level, showed the strongest effects by enhancing yolk color, reducing MDA, increasing TAC and TPC, and promoting higher Σ PUFA and ω 6 fatty acids.

Table 1

Fatty acids	Control	Garlic low	Garlic high	Onion low	Onion high	Paprika low	Paprika high	SEM	P
Σ SFA	24.09	23.96	25.38	23.56	24.88	26.21	25.46	0.28	0.088
Σ MUFA	14.55	14.75	15.46	15.52	16.53	16.35	17.90	0.33	0.067
Σ PUFA	8.52 ^c	8.92 ^{bc}	10.25 ^{ab}	8.91 ^{bc}	10.18 ^{ab}	9.86 ^{abc}	10.38 ^a	0.18	<0.001
ω 3	0.49	0.52	0.59	0.60	0.65	0.60	0.71	0.02	0.252
ω 6	7.97 ^b	8.34 ^{ab}	9.61 ^a	8.18 ^{ab}	9.47 ^a	9.21 ^{ab}	9.53 ^a	0.18	0.004

Table 2

Egg quality parameters	Parameter	Control	Garlic low	Garlic high	Onion low	Onion high	Paprika low	Paprika High	SEM	P
1 st Sampling	Egg weight (g)	63.67	61.45	64.00	59.57	63.42	64.20	59.18	0.76	0.360
	Shell weight (g)	6.35	5.95	5.68	5.70	5.70	6.05	5.85	0.12	0.751
	Shell thickness (mm)	0.356 ^{ab}	0.315 ^{ab}	0.315 ^{ab}	0.295 ^b	0.300 ^{ab}	0.332 ^{ab}	0.371 ^a	0.01	0.019
	Yolk color (Roche)	11.67 ^{bc}	11.58 ^c	11.92 ^{abc}	11.00 ^c	11.25 ^c	12.75 ^{ab}	12.92 ^a	0.08	<0.001
	Yolk weight	15.78 ^b	20.42 ^a	18.08 ^{ab}	19.07 ^{ab}	16.38 ^b	17.77 ^{ab}	19.20 ^{ab}	0.39	0.012
	Yolk pH	5.88	6.07	6.10	5.93	5.93	6.25	6.12	0.05	0.437
	Albumen pH	8.22	8.08	7.98	8.20	7.93	7.93	7.93	0.04	0.086
2 nd Sampling	Egg weight (g)	59.47	62.83	64.24	62.85	64.81	65.23	62.98	0.87	0.337
	Shell weight (g)	6.00	5.46	6.28	5.41	5.77	5.98	5.61	0.11	0.158
	Shell thickness (mm)	0.31	0.34	0.35	0.32	0.35	0.36	0.34	0.01	0.074
	Yolk color (Roche)	11.08 ^b	8.92 ^c	10.92 ^b	8.50 ^c	9.17 ^c	12.08 ^a	12.75 ^a	0.26	<0.001
	Yolk weight	17.63	18.40	17.70	19.60	19.14	18.38	17.08	0.42	0.713
	Yolk pH	5.92 ^{ab}	5.61 ^b	5.80 ^{ab}	6.26 ^a	5.63 ^{ab}	5.82 ^{ab}	5.65 ^{ab}	0.06	0.046
	Albumen pH	8.36	8.18	8.37	8.20	8.55	8.22	7.87	0.05	0.077
3 rd Sampling	Egg weight (g)	60.58	65.54	67.73	62.15	68.15	66.66	63.01	0.89	0.141
	Shell weight (g)	6.22	6.59	6.71	6.40	6.26	6.30	6.25	0.07	0.077
	Shell thickness (mm)	0.35	0.35	0.34	0.31	0.31	0.32	0.32	0.01	0.058
	Yolk color (Roche)	12.00 ^{abc}	11.92 ^{bc}	12.33 ^{ab}	11.42 ^c	11.75 ^{bc}	12.33 ^{ab}	12.83 ^a	0.09	<0.001
	Yolk weight	18.45	21.17	20.73	17.56	19.46	20.71	19.96	0.36	0.159
	Yolk pH	6.45 ^a	6.20 ^{ab}	5.96 ^{ab}	6.10 ^{ab}	5.93 ^{ab}	5.83 ^b	5.99 ^{ab}	0.06	0.049
	Albumen pH	7.85	7.98	8.17	8.05	8.14	8.03	8.02	0.03	0.217
4 th Sampling	Egg weight (g)	64.05	64.78	65.80	64.57	67.40	68.85	63.37	0.59	0.145
	Shell weight (g)	5.40	5.85	6.29	5.95	5.77	6.37	5.75	0.09	0.056
	Shell thickness (mm)	0.30	0.29	0.28	0.32	0.29	0.33	0.33	0.01	0.071
	Yolk color (Roche)	12.25 ^{ab}	12.17 ^{ab}	11.83 ^b	12.25 ^{ab}	12.17 ^{ab}	12.42 ^{ab}	12.75 ^a	0.17	0.036
	Yolk weight	18.51	19.55	18.35	19.44	18.53	19.97	17.96	0.25	0.289
	Yolk pH	6.08 ^{ab}	5.96 ^b	6.13 ^{ab}	6.06 ^{ab}	5.91 ^b	6.24 ^a	6.00 ^{ab}	0.02	0.006
	Albumen pH	8.13	8.11	8.14	8.28	8.14	8.03	8.06	0.03	0.274
Overall experimental period	Egg weight (g)	61.94	63.65	65.44	62.29	65.95	66.24	62.14	0.54	0.087
	Shell weight (g)	5.99	5.96	6.24	5.78	5.88	6.18	5.87	0.05	0.167
	Shell thickness (mm)	0.33	0.32	0.32	0.31	0.31	0.34	0.34	0.01	0.087
	Yolk color (Roche)	11.75 ^b	11.15 ^c	11.75 ^b	10.79 ^c	11.08 ^c	12.40 ^a	12.82 ^a	0.11	<0.001
	Yolk weight	17.59	19.64	18.67	18.92	18.38	19.21	18.55	0.22	0.331
	Yolk pH	6.08 ^{ab}	5.96 ^{ab}	6.00 ^{ab}	6.09 ^a	5.85 ^b	6.04 ^{ab}	5.94 ^{ab}	0.02	0.035
	Albumen pH	8.14	8.09	8.17	8.18	8.19	8.06	7.97	0.02	0.098

Table 3

Antioxidant status	Sampling	Time	Control	Garlic low	Garlic high	Onion low	Onion high	Paprika low	Paprika high	SEM	P	
MDA (ng/g)	1 st	30	35.6	36.3	33.5	37.2	30.3	45.8	25.2	2.02	0.196	
		60	38.8	39.1	35.8	41.8	33.9	54.7	32.8	2.16	0.112	
	2 nd	30	46.3 ^a	35.7 ^{abc}	32.6 ^{abc}	40.0 ^{ab}	28.3 ^{bc}	41.1 ^{ab}	21.2 ^c	1.81	<0.001	
		60	53.8	43.4	42.0	48.0	33.9	51.0	32.1	2.32	0.077	
	3 rd	30	24.3 ^{ab}	25.3 ^{ab}	21.7 ^{ab}	27.7 ^a	16.9 ^{abc}	14.6 ^{bc}	6.8 ^c	1.44	<0.001	
		60	31.9	29.8	25.2	33.8	23.2	24.4	12.7	2.00	0.080	
	4 th	30	46.0 ^a	22.3 ^{bc}	24.1 ^{bc}	15.5 ^c	15.8 ^c	24.0 ^{bc}	32.1 ^b	1.81	<0.001	
		60	54.4 ^a	28.7 ^b	33.1 ^b	20.7 ^b	23.1 ^b	34.9 ^b	39.8 ^{ab}	2.34	<0.001	
	Total	30	38.1 ^a	29.9 ^{bc}	28.0 ^{bcd}	30.1 ^{bc}	22.8 ^{cd}	31.4 ^{ab}	21.3 ^d	1.06	<0.001	
		60	44.8 ^a	35.2 ^{ab}	34.0 ^{ab}	36.1 ^{ab}	28.5 ^b	41.2 ^{ab}	29.3 ^b	1.37	0.006	
	TAC (μ g AAE/g)	1 st	-	42.4 ^{ab}	39.5 ^b	42.2 ^{ab}	41.9 ^{ab}	45.0 ^a	44.9 ^a	45.7 ^a	0.54	0.012
		2 nd	-	28.9 ^c	36.0 ^b	34.5 ^b	34.5 ^b	36.9 ^{ab}	38.8 ^{ab}	40.6 ^a	0.66	<0.001
2 nd		-	30.4 ^b	29.3 ^b	31.8 ^b	30.4 ^b	37.0 ^{ab}	39.2 ^a	40.5 ^a	0.94	<0.001	
4 th		-	40.9 ^c	43.1 ^{bc}	42.8 ^c	45.7 ^{ab}	46.6 ^a	48.0 ^a	47.6 ^a	0.47	<0.001	
Total		-	35.6 ^b	37.0 ^b	37.8 ^b	38.1 ^b	41.4 ^a	42.7 ^a	43.6 ^a	0.52	<0.001	
Total		-	4152	4583	4712	4281	3871	4471	4935	108	0.141	
TPC (μ g GAE/g)	2 nd	-	3113	3048	3251	3342	3463	3231	3708	66	0.124	
	3 rd	-	3046 ^c	2949 ^c	3227 ^{bc}	3159 ^c	3785 ^{ab}	2774 ^c	4209 ^a	91	<0.001	
	4 th	-	4878	4987	4752	5049	4523	4112	5113	143	0.536	
	Total	-	3797 ^b	3892 ^b	3985 ^b	3958 ^b	3844 ^b	3647 ^b	4491 ^a	56	<0.001	