

Comparison of Two Dietary Factors, Green Tea Powder Feeding and Feed Restriction, Influencing Laying Performance and Egg Quality in Hens

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Abstract

Laying performance and egg quality were monitored, using 15 hens fed a diet with or without 0.3% green tea powder *ad libitum* (GTP or control), or non-supplemented diet restrictedly (Restricted). The restricted group was fed the daily amount of the diet that was recorded on the previous day in the GTP group, since GTP had been found to reduce feed intake. The birds were reared from 30 to 42 weeks of age. Feed intake of the GTP group was significantly lower ($P<0.05$) except for the first three weeks, than that of the control group. Neither GTP nor feed restriction significantly affected the body weight of experimental hens. Egg production rate was mostly the same in all three groups. GTP feeding lowered average egg weight ($P<0.05$), while feed restriction did not. The Haugh Unit was improved significantly ($P<0.05$) in GTP feeding in both fresh and stored eggs when compared with the control, and the units were significantly higher ($P<0.05$) in the GTP group than in the restricted group as well. Albumen thickness and albumen percentage were higher ($P<0.05$) and yolk percentage was lower ($P<0.05$) in both the GTP and restricted groups. These are more pronounced in fresh eggs. Egg yolk cholesterol level was significantly lower ($P<0.05$) in the GTP group than in the other two groups. Feed restriction reduced ($P<0.05$) blood urea-N and glucose levels.

These results show that some favorable physicochemical characteristics of eggs such as low cholesterol yolk and higher Haugh Unit were mainly caused by GTP feeding. Eggs showing higher Haugh Unit with thicker albumen are also produced by feed restriction but to a lesser extent.

Key words: green tea powder, egg, Haugh unit, albumen, layer

Introduction

Influences of long-term feeding of Japanese green tea powder (GTP) on laying performance and egg quality in hens were previously studied¹⁾, in which Haugh Unit score (HU) and albumen height of stored eggs were favorably improved by GTP feeding. However, it has not been clearly defined whether these improvements are results by either the effect of GTP or by the reduction of feed intake that was accompanied with GTP treatment. A series of experiments have been done to study the effect of restricted feeding on a layer's performance and quality of the products. Shell strenght of

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eggs was significantly improved by restricted feeding at 76-84 % of the recommended level²⁹. Mbugua and Cunningham³⁰ reported that quantitatively restricted feeding increased the number of large eggs and eventually the net income by decreasing feed consumption. Skip-a-day restricted feeding in the early stage improves egg production³¹.

Very few studies have found the net effect of GTP in feed on the growth and products of domestic animals. The tea polyphenol has a deodorizing effect on pig feces, possibly modifying fecal metabolite composition³². The feeding of tea extracts to laying hens improved egg quality by increasing albumen thickness and decreasing crude fat in egg yolk in a quite short-term (6 weeks) experiment³³. In these experiments, the intake level was similar between treatments, suggesting the potencies of GTP itself.

In the present experiment, we evaluated two different dietary factors, GTP feeding and restricted feeding, both possibly influencing the laying performance and egg quality. Through this evaluation we expect to conclude which could be the main factor leading to favorable characteristics of eggs such as high durability of thick albumen and less cholesterol in yolk observed in the previous experiment.

Materials and Methods

Birds and management

Fifteen Rhode Island Red layers at 30 weeks of age were obtained from Mie University farm. The birds were weighed and divided into three groups each consisting of 5 birds. The birds were reared individually in a wire-fenced cage with normal layer lighting schedule. The control group was fed with the commercial diets of Hyper Layer (17.0% CP and 2830 kcal ME/kg, Tokai Feed Manufacturing Co. Ltd), the second group was fed with the same diet but supplemented with 0.3% green tea powder (GTP group) which was donated by Department of Tea-Raising, Agricultural Research Center, Mie Prefectural Science and Technology Promotion Center, Japan. The third group was fed with the normal diet (not GTP diet) but the amount of feed was restricted to be comparable to that of the GTP group (Restricted group), *i. e.* the amount of feed taken by the GTP group on the previous day was supplied to the restricted group. All the groups were freely accessible to water throughout the experiment (30-42 weeks of age).

Physical measurements

The feed consumption was measured everyday during the period from 30 to 42 weeks of age. The body weight was measured every four weeks within the experimental period. The egg production rate in the laying period was recorded. Physical parameters of eggs such as egg weight, shell strength, shell thickness, albumen weight, yolk weight, and Haugh Unit were monitored during storage for 0 and 10 days at room temperature. Shell thickness was measured at three positions of each shell using a micrometer (Peacock, Tokyo). Shell-breaking force was monitored by a plunge instrument (Fujihara Co. Tokyo). Height and weight of the albumen and yolk were also measured after separation of each part from a whole egg. On the last day of the experiment, blood was collected from the heart and the serum was obtained by centrifuging (at 1,200 x g for 20 minutes) and

preserved at -82°C until analysis.

Chemical analysis

Egg yolk cholesterol was photometrically assayed through a Killiani reaction after extracting with ethanol/acetone (50/50, v/v) in a rotator at 37°C for 24 hours⁷. Urea-N, glucose, triglyceride, GOT and ammonia-N of the blood serum was evaluated on an automatic analyzer (Fuji dry chemical system). All the chemicals used were of reagent grade (Nacalai tesque, Japan).

Statistical analysis

Average values for the parameters measured for each replicate were employed for the analysis of variance. Duncan's multiple range test was used to separate means when they were statistically significant.

Results and Discussions

Body weight and feed intake during the period from 30 to 42 weeks of age are presented in Table 1. Body weight tended to be lower in GTP and restricted groups than in the control group, though the differences were not significant. Feed intake of the GTP group was decreased significantly ($P < 0.05$) at all periods except the period from the first through the third week. Consequently, the restricted group had significantly lower feed intake ($P < 0.05$). The average feed intakes per day throughout the experiment were 111, 102 and 101g for the control, GTP and restricted groups,

Table 1. Effects of dietary Japanese green tea powder supplementation and feed restriction on body weight and feed intake of laying hens reared from 30 to 42 weeks of age.

Age (weeks)	Body weight (g)			Feed intake (g/bird/day)		
	Control	GTP	Restricted	Control	GTP	Restricted
30	1928	1938	1944	-	-	-
31				102	103	100
32				108	104	102
33				109	102	103
34	1976	1886	1846	115 ^b	101 ^a	100 ^a
35				113 ^b	99 ^a	101 ^a
36				109 ^b	101 ^a	98 ^a
37				110 ^b	99 ^a	100 ^a
38	1932	1822	1707	112 ^b	101 ^a	99 ^a
39				114 ^b	104 ^a	102 ^a
40				117 ^b	107 ^a	103 ^a
41				114 ^b	104 ^a	105 ^a
42	2108	2002	1922	111 ^b	101 ^a	100 ^a
30-42				111 ^b	102 ^a	101 ^a

Each value represents the mean (n=5 for body weight and n=7 for feed intake), ^{a,b,c}: means with different superscript within the same row are significantly different ($P < 0.05$).

respectively. This decrease in feed intake, recorded as 92% of control, is in good agreement with the previous results¹⁾ with a higher dose of GTP (0.6 vs 0.3%). The obtained results on laying performance and egg quality were evaluated whether they are affected by GTP or feed restriction, or both.

Egg production rate and egg weights are shown in Table 2. The average egg production rates throughout the experiment were recorded to be 77.4, 79.1 and 77.9% for the control, GTP and restricted groups, respectively. These show no significant change with treatment. Average egg weights throughout the experimental period were 61.7, 60.2 and 60.8g for the control, GTP and restricted groups, respectively. There was a significant difference only between the control and GTP groups. However, this should not be pronounced since the absolute difference is small. Overall, general laying performance such as body weight, egg production rate and egg size were not affected much by either GTP or restricted feedings.

Some physical and chemical parameters defining egg quality were affected more by GTP and feed restriction (Tables 3). Haugh Unit score of eggs became significantly higher ($P < 0.05$) in the GTP and restricted groups depending on, whether the eggs were fresh or stored. GTP was more potent in this improvement ($P < 0.05$) than feed restriction. Albumen thickness was also significantly improved by GTP and feed restriction. Albumen tended to be thicker in GTP than feed restriction (not significant). Even though not clearly evidenced, GTP is more likely influential in preventing thinning of thick albumen rather than feed restriction. This may be, as discussed in the previous Paper¹⁾, caused by possible transfer of polyphenols of GTP into β -ovomucin that increases albumen durability by forming complexes with proteins and polysaccharides²⁾. GTP and restricted feedings,

Table 2. Effects of dietary Japanese green tea powder supplementation and feed restriction on egg production and egg weight of laying hens reared from 30 to 42 weeks of age.

Age (weeks)	Egg production (%)			Average egg weight (g)		
	Control	GTP	Restricted	Control	GTP	Restricted
31	80.0	85.7	80.0	59.7	58.7	58.7
32	82.9	85.7	85.7	60.6 ^b	59.3 ^a	59.6 ^{ab}
33	68.6	91.4	74.3	59.6 ^b	58.3 ^a	59.1 ^{ab}
34	80.0	82.9	77.1	61.3 ^b	59.7 ^a	60.0 ^{ab}
35	77.1	74.3	68.6	62.1 ^b	59.9 ^a	61.1 ^{ab}
36	77.1	71.4	82.9	61.4	60.1	60.9
37	77.1	82.8	88.6	61.9	61.3	61.4
38	80.0	71.4	80.0	62.7	61.7	62.4
39	80.0	77.4	74.3	63.4	60.4	61.1
40	91.4	80.0	74.3	61.9	60.7	62.0
41	71.1	71.4	82.9	63.1	61.4	61.9
42	62.9	74.3	65.7	62.6 ^b	60.6 ^a	61.4 ^a
30-42	77.4	79.1	77.9	61.7 ^b	60.2 ^a	60.8 ^{ab}

Each value represents the mean ($n=5$ for egg production, $n=22-31$ for egg weight), ^{a, b}: means with different superscript within the same row in each parameter are significantly different ($P < 0.05$).

both increased the fresh egg albumen proportion ($P<0.05$), while decreased the fresh egg yolk proportion ($P<0.05$). Extents of the increase and the decrease were higher in restricted feeding than GTP feeding ($P<0.05$ and no significance, respectively). Therefore, these variations are mainly reflected by feed restriction, though the previous results were opposite. Shell weight proportion in fresh eggs was reduced ($P<0.05$) by restricted feeding, though shell strength and thickness in the restricted group did not differ from those in the other two groups. GTP significantly increased ($P<0.05$) shell strength when compared with the control. Egg yolk color did not differ among all 3 groups. As reported before⁹, these are not parameters that are affected much by GTP and feed restriction.

Table 3. Effects of dietary Japanese green tea powder supplementation and feed restriction on physicochemical properties of egg at different storing period.

Parameters	0 day (fresh)			10 days		
	Control	GTP	Restricted	Control	GTP	Restricted
Haugh Unit	72.00 ^a	85.00 ^c	79.00 ^b	36.00 ^a	54.00 ^c	45.00 ^b
Albumen thickness (mm)	9.13 ^a	9.99 ^b	9.71 ^b	2.16 ^a	3.45 ^b	3.01 ^b
%Albumen weight	54.63 ^a	56.95 ^b	58.85 ^c	55.76	56.12	56.76
%Shell weight	13.83 ^b	13.81 ^b	12.83 ^a	13.53	13.21	13.06
%Yolk weight	31.11 ^b	29.24 ^a	28.32 ^a	30.71	30.67	30.17
Shell strength (kg/cm ²)	3.32 ^a	4.19 ^b	3.73 ^{ab}	3.30	2.92	2.91
Shell thickness (mm)	0.32	0.32	0.33	0.35	0.35	0.35
Egg yolk color	9.10	9.50	8.60	nd	nd	nd
Egg yolk cholesterol (mg/g)	21.79 ^b	19.76 ^a	21.90 ^b	nd	nd	nd

Each value represents the mean ($n=12$), ^{a,b,c}: means with different superscript within the same row in each stored period are significantly different ($P<0.05$). Measurements were done on the eggs produced at 31, 36 and 42 weeks of age, nd: not determined.

Table 4. Effects of dietary Japanese green tea powder supplementation and feed restriction on blood serum components of laying hens at 42 weeks of age.

Parameters	Control	GTP	Restricted
Urea nitrogen (mg/dl)	0.84 ^b	0.66 ^b	0.32 ^a
Glucose (mg/dl)	252.80 ^b	259.80 ^b	235.20 ^a
Triglyceride (mg/dl)	407.80	429.60	414.60
GOT ($\mu\text{mol/l}$)*	119.40	115.40	115.60
Ammonia nitrogen ($\mu\text{g/dl}$)	222.00	225.80	179.00

Each value represents the mean ($n=5$), ^{a,b}: means with different superscript within the same row are significantly different ($P<0.05$). * Activity of GOT (glutamic oxalacetic transaminase) was expressed as μmol of pyruvate/l of serum.

Cholesterol concentration in the egg yolk significantly decreased in the GTP group ($P < 0.05$), but not in the restricted group. Obviously, this is caused only by GTP, and has been demonstrated together with reduction of total lipid^{1,6}. Also the reduced cholesterol in the liver and blood, and less total fat in the liver and meat were observed in broilers given GTP (BISWAS and WAKITA manuscript in preparation). These alterations are generally appreciated by consumers of the products.

Blood serum components are shown in Table 4. Overall, the components showed similar values in all 3 groups, though significant decreases are detected for urea nitrogen and glucose concentrations in the restricted group when compared with those in the other 2 groups. These indicate that restricted feeding might have negative effects on protein and energy metabolism of hens, but GTP feeding does not.

In conclusion, some favorable profiles of eggs as characterized by a lower yolk cholesterol and a higher Haugh Unit, could be promised mainly by GTP feeding. A higher Haugh Unit and a thicker albumen are also expected by feed restriction, but to a lesser extent. The present experiment was carried out, using a limited number of layers. Therefore, the conclusion drawn here apparently waits further confirmation.

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ニワトリの産卵成績と卵質に及ぼす食餌性二要因，緑茶粉末給与と飼料給与量制限，の比較

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15羽の産卵鶏を供試し，緑茶粉末（Green tea Powder: GTP）の無添加飼料（対照区）および0.3%添加飼料（GTP区）を自由摂取させた場合とGTP添加飼料給与区とほぼ同じ飼料摂取量になるように給与量を制限した区（制限区）の産卵成績と卵質について30～42週齢の間で調査した。GTP区の飼料摂取量は，試験開始後の3週間を除いて対照区に対して有意（ $p < 0.05$ ）に減少した。体重はGTP区及び制限区とも顕著な影響は見られなかった。産卵率は3区ともほとんど同じであった。GTP区の平均卵重は有意（ $p < 0.05$ ）に低下したが，制限区は変化はなかった。GTP給与によって新鮮卵および貯蔵卵のハウユニット値は対照区より有意（ $p < 0.05$ ）に改善され，制限区より有意（ $p < 0.05$ ）に高いものであった。GTP区と制限区では卵白厚と卵白割合が高く，卵黄割合が低くなった。これらの変化は新鮮卵でより明確であった。GTP区の卵黄コレステロールレベルは他の二区より有意（ $p < 0.05$ ）に低いものであった。制限区の血液中の尿素態窒素とグルコースレベルは有意（ $p < 0.05$ ）に減少した。

これらの結果より，低卵黄コレステロールおよび高ハウユニット値など鶏卵として好ましい理化学的性質の変化は主にGTP給与によって生ずることを示した。制限給餌によっても高卵白厚，高ハウユニット値になるが，その程度は低いものであった。