Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(7):176-181

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Effect of emulsified fat powder on the laying performance, egg quality, serum biochemical parameters and antioxidant activity

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ABSTRACT

This study was conducted to determine the effects of emulsified fat powder on laying performance, egg quality, serum biochemical parameters and antioxidant activity. Four hundred 300-day-old Rohman laying hens were randomly divided into 4 dietary treatments of 100 each. Each treatment had 4 replicates, and each replicate had 5 cages with 5 hens per cage. The control group was fed with basal diet, and the experimental groups I, II and III were supplemented with 1%, 3% and 5% emulsified fat powder, respectively. The adjustment period lasted for 7d and the experimental period lasted for 30d. The results showed that dietary 3% fat powder supplementation increased the rate of egg laying and mean egg weight (P<0.05) and decreased the broken egg rate (P<0.05). Serum total protein, albumin and globulin concentration increased significantly in response to supplemental fat poeder and was also maximised at 3%. In addition, serum glucose and blood urea nitrogen (BUN) significantly decreased (P<0.05). The content of total cholesterol (TC) and total triglyceride (TG) of all experimental groups decreased compared with that of the control group, and 3% addition groups was the lowest (P<0.05). Compared with the control group, the activities of superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) in the serum of all the trial groups were significantly increased (P<0.05), while the content of serum malondialdehyde (MDA) reduced. These results suggested the emulsified fat powder could improve the laying performance, enhance the egg quality and oxidation resistance.

Keywords: emulsified fat powder, performance, egg quality, biochemical profiles

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INTRODUCTION

Oil has been widely used in animal production, which can not only afford the high energy supply, provide the essential fatty acids, improves the palatability of the diet and promote other nutrients digestion and absorption, but also it has regulate immune function and relieve stress responses in animals. It was well established that hens generally adjust their feed intake according to their energy requirements [1]. Heavy hens had higher feed intake and produced heavier eggs and more egg mass than light hens. However, feed and energy efficiency were better for the lighter hens [2]. An increase in the energy content of the diet improved FCR from 0 to 17 wk of age [3]. Therefore, the oil as a high-energy feed raw material was widely used in animal diet and achieved many favourable performances. However, the oil widely used in animal diet has many disadvantages such as the inconvenient adding, inaccurate measurement, and easily oxidized. These features can lead to the poor palatability of diet, and decrease the nutritional value and digestibility. Fat powder is a kind of powdered oil, which is processed by various kinds of plant oils (such as palm oil, coconut oil) and emulsifier. Compared with the common oils, fat powder is not only easy to use, weighing and storage, but also has the advantages of not oxidation in summer and without solidification in winter. In the present study, the effects of emulsified fat powder on laying performance, egg quality, serum biochemical parameters and antioxidant activity were determined.

EXPERIMENTAL SECTION

Birds and diet

The experiment was approved by and performed in accordance with the guidelines of the local ethics committee. A total of 400 Rohman hens, 300 days of age and from a commercial layer farm, with similar performance were randomly allocated to 4 treatment groups, each of which included 4 replicates of 25 hens. The control group was fed with basal diet, and the experimental groups I, II and III were supplemented with 1%, 3% and 5% fat powder, respectively. The adjustment period lasted for 7d and the experimental period lasted for 30d. Ingredient composition and analysed nutrients were presented in Table 1.

Table 1 Composition and nutrient level of diets

Ingredients (%)		*Nutrient composition*	
Corn	63.27	ME	11.03 MJ/kg
Soybean meal	25.90	CP	16.30%
Salt	0.30	Lys	0.83%
$CaHPO_4$	1.50	Met	0.33%
Limestone	8.80	Ca	3.50%
DL-Methionine	0.08	Total P	0.58%
Choline chloride	0.10	Avaiable P	0.37%
Vitamin premix	0.02		
Mineral premix	0.03		
Total	100.00		

Note：provided per kg diet：VA 1500IU, VD_3 200IU, VE 10IU, VK 0.50mg, VB_{12} 0.01mg, biotin 0.15 mg, folic acid 0.55 mg, niacin 30 mg, pantothenic acid 10mg, pyridoxine 3.5 mg, riboflavin 3.6 mg, thiamine 1.8mg, Cu 8mg, I 0.35mg, Fe 80mg, Mn 60mg, Se 0.30mg, Zn 80mg.

Emulsified oil powder, a kind of soybean oil emulsion of balanced powder, was purchased from Shandong Lvdu Ante Animal Drug Co. Ltd. The color is pale yellow, the composition: crude fat ≥60%, crude protein ≥3. 2%, the total energy 6750 kcal/kg; fatty acid composition: 11% of palmitic acid, 12% of oleic acid, 3.5% of linolenic acid, 2.3% of stearic acid, 30.2% of linoleic acid .

The hens were housed at 5 birds per cage under the same managerial conditions in a windowed poultry house. Hens were kept in 3-layer complete ladder cages and fed ad libitum twice daily at 06:00 and 14:00 h; water nipples were available at all times. The photoperiod was 16L:8D throughout the experiment. During the experiment period, all the houses were kept cleanly and regularly disinfected, and the hens were immunized according to the routine immunization procedures. The temperature, humidity and ventilation conditions were in accordance with the conventional control group.

Sample collection

After 30d, three hens per treatment were slaughtered by cervical dislocation and blood samples were collected. After incubation at 4℃ for 30 min and centrifugation at 3000g for 10min, the serum was obtained (Centrifuge 5804R, Eppendorf, Germany). Samples were finally frozen and kept at −80℃ for no more than 2 months until further analysis.

Performance

During the study period, eggs were collected on a daily basis (at 9:00 am) and weighed immediately. The data (egg number and weight) were used to calculate egg mass. Performance parameters including feed consumption, egg production, egg weight, egg mass, and feed conversion ratio were measured.

Egg quality

Three eggs (15 eggs per each treatment group) were collected from each replicate on 15d and 30d, and egg quality indices including yolk index, Haugh unit, eggshell weight, eggshell thickness, and eggshell breaking strength were measured.

Serum biochemical parameters

The concentration of serum total protein, albumin, globulin, glucose, urea nitrogen, total cholesterol (TC), triglyceride (TG), calcium (Ca) and phosphorus (P) were measured by automatic biochemical analyzer (Shanghai All-Time Commercial Co., Ltd, China). The serum glutathione peroxidase (GSH-Px), superoxide dismutase (SOD) activity and the content of malondialdehyde (MDA) were detected by the kit produced by Nanjing Biological Engineering Research Institute, China.

Statistical analysis

Data are expressed as mean±standard deviation (SD) and were analyzed using the one-way analysis of variance (ANOVA) procedure of SPSS 16.0 (SPSS Inc., Chicago, IL, USA) for Windows by the Tukey test and the variable used is the administration of B10. Differences were considered statistically significant at $P<0.05$.

RESULTS AND DISCUSSION

Effect of emulsified fat powder on the performance of laying hens

As shoen in Table 2, the supplementation of emulsified fat powder can increase the laying rate and average egg weight, and decrease the rate of broken (soft) eggs. Compared with the control group, the laying rate of the experiment groups increased 3.38% ($P<0.05$) and 6.76% ($P<0.05$) and 2.22% ($P>0.05$), respectively. The average egg weight of the experimental groups increased by 4.85%, 6.50% and 7.64% ($P< 0.05$) with that of control group, respectively, but there was not significant between the experimental groups ($P>0.05$). The rate of broken (soft) eggs reduced 21.95%, 63.42%, and 60.98% ($P<0.05$), there was not significant between the group II and group III ($P>0.05$). There effect of the emulsified fat powder on the abnormal egg rate was not significant ($P>0.05$).

Table 2 The effect of the emulsified fat powder on the laying performance

Item	Control group	Group I (1%)	Group II (3%)	Group III (5%)
Laying rate (%)	58.22±0.67^{a}	60.20±0.45^{b}	62.16±0.37^{c}	59.50±0.32^{ab}
Average egg weight (g)	42.68±0.12^{a}	44.76±0.23^{b}	45.46±0.45^{b}	45.94±0.27^{b}
Abnormal egg rate (%)	0.77±0.01^{ab}	0.86±0.02^{b}	0.66±0.02^{a}	0.74±0.02^{ab}
Broken (soft) egg rate (%)	0.42±0.02^{a}	0.33±0.01^{b}	0.15±0.01^{c}	0.17±0.02^{c}

Note: Different letters indicate a statistically significant difference.

Many researchers have reported that increasing dietary energy by addition of corn oil or poultry oil increases early egg weight [4, 5]. Emulsified fat powder as a high energy feed additive can improve the energy concentration of the diet, and enhence the performance of animal production and the feed conversion efficiency. In this study, the results showed that the laying rate increased by 3.38%, 6.76% and 2.22%, the average egg weight increased by 4.85%, 6.50% and 7.64% compared with the control group. These results suggested that the emulsified fat powder could improve the egg production rate and the average egg weight of laying hens, the reason may be the addition of the emulsified fat powder improve the energy level of the basal diet and provide essential fatty acids and efficient generation of metabolic energy for hens. Increasing dietary energy by the addition of poultry oil increased early egg weight, which was mostly due to increased yolk weight [6]. Supplemental fat has often resulted in increased egg weight [7]. The emulsified fat powder used in this experiment was a kind of high energy feed additive and a compound vegetable oil, it has high amount of emulsification and rich in unsaturated fatty acid. With higher levels of emulsified fat powder added, broken (soft) egg rate and dirty eggs rate showed a decline trend, but abnormal egg rate was no change. The reason may be the addition of emulsified fat powder promote the absorption of fat soluble vitamin and increase the absorption and utilization of nutrients.

Effect of the emulsified fat powder on the egg quality

The addition of emulsified fat powder had no significant effect on the egg shape index (Table 3); and the Haugh unit value of group II was highest compared with other groups. experimental group II of the was significantly high. The yolk color series of experimental group I, II, and III increased 3.45%, 13.79%, and 17.24%, respectively compared with that of the control group, of which the group III group and the control group had significant difference. The eggshell thickness of all the experimental groups were higher than that of the control group, the eggshell thickness of group III was significantly higher (8.82%) than that of the control group. There was no significant difference between group I, group II and the control group.

Table 3 The effect of the emulsified fat powder on the egg quality

Item	*Control group*	*Group I (1%)*	*Group II (3%)*	*Group III (5%)*
Egg shape index	1.37±0.02^{a}	1.38±0.01^{a}	1.34±0.02^{a}	1.35±0.03^{a}
Haugh unit	75.09±0.34^{b}	75.54±0.26^{b}	77.22±0.17^{a}	75.01±0.55^{b}
Yolk color	7.49±0.12^{b}	7.75±0.24^{ab}	8.54±0.16^{ab}	8.79±0.21^{a}
Shell thickness (mm)	0.35±0.02^{b}	0.36±0.01^{ab}	0.37±0.01^{ab}	0.38±0.02^{a}

Note: Different letters indicate a statistically significant difference.

Egg shape index is one of the important indicators for layer classification, and each kind of layer has a certain egg shape index. In this experiment, there was no significant effect of the emulsified fat powder on egg shape index, and the egg shape index of all the groups were within the range of egg shape index of normal eggs. The Haugh unit is an important index to measure the quality of egg protein. The greater Haugh unit value indicates the highe protein viscosity, the better the quality of egg protein. In this study, addition of different levels of emulsified fat powder

increased the Haugh unit value, indicating that emulsified fat powder could improve the quality of egg protein, improve the digestion and utilization of nutrients. Egg yolk color is one of the most important sensory indicators to measure egg quality. It is generally believed that the yolk color is related to the content of lutein in the diet. Lutein is a fat soluble substance. Therefore, the addition of emulsified fat powder in the diet can promote the absorption of lutein and improve the color of egg yolk. The results of this experiment showed that the dietary emulsified fat powder can increase the color of egg yolk. Eggshell thickness is mainly affected by feed in Ca, P, trace elements and vitamins. Small changes of the content Ca and P has great influence on the thickness of eggshell. In this study, the emulsified fat powder may promote the absorption of Ca and P in diet, and increase the formation of eggshell calcium, thereby increasing the thickness of egg shel. The contents of serum P and Ca reflected the metabolism of Ca and P in the formation of eggshell. The serum Ca and P levels increased and the eggshell quality increased.

Effect of the emulsified fat powder on serum biochemical parameters

As shown in Table 4, the addition of emulsified fat powder can increase the content of serum total protein, albumin and globulin content, and decrease the content of serum glucose and urea nitrogen. Compared with the control group, the serum glucose content in the experimental groups were reduced by 3.88% ($P>0.05$), 10.93% ($P<0.05$) and 11.63% ($P<0.05$), respectively; the serum urea nitrogen (BUN) content in three experimental groups were reduced by 9.46% ($P>0.05$), 28.38% ($P<0.05$) and 21.62% ($P<0.05$), respectively; the content of total protein content were increased by 13.31%, 14.44% and 14.92% ($P<0.05$), respectively. With the dietary level of emulsified fat powder increasing, the content of serum total protein increased linearly. The serum albumin content in the experimental groups increased by 18.12% and 17.49%, 13.61% ($P<0.05$) compared with the control group, but there no significant difference between the three experimental groups; compared with the control group, the serum globulin content in the experimental groups were increased by 9.52%, 15.02% and 13.25% ($P<0.05$), there was no significant difference between group II and group III ($P>0.05$).

Compared with the control group, the total cholesterol (TC) content of the three experimental groups decreased, the content of TC in group II was the lowest; the serum triglyceride (TG) levels in the three experimental groups were significantly lower than the control group, but there was no significant difference between the experimental groups. Serum P content increased by 2.59%, 7.33% and 3.88%, respectively. Serum Ca content in group III was the highest between the four groups, and significantly higher than that of the control group and group I, but there was no significant difference compared with that of group II.

Table 4 The effect of the emulsified fat powder on serum biochemical parameters

Item	*Control group*	*Group I (1%)*	*Group II (3%)*	*Group III (5%)*
Glucose (mmol/L)	8.80 ± 0.33^{a}	8.46 ± 0.26^{ab}	7.86 ± 0.35^{c}	7.77 ± 0.19^{bc}
Urea nitrogen (mmol/L)	0.77 ± 0.02^{a}	0.69 ± 0.01^{bc}	0.56 ± 0.02^{c}	0.60 ± 0.01^{bc}
Total protein (g/L)	49.46 ± 2.25^{c}	56.05 ± 1.22^{b}	56.62 ± 1.17^{ab}	56.83 ± 1.90^{a}
Albumin (g/L)	20.44 ± 0.78^{a}	24.17 ± 0.39^{b}	23.22 ± 0.24^{b}	24.01 ± 0.75^{b}
Globulin (g/L)	29.70 ± 0.22^{a}	32.53 ± 0.38^{b}	34.17 ± 0.27^{c}	33.64 ± 0.19^{bc}
TC (mmol/L)	2.56 ± 0.02^{a}	2.47 ± 0.01^{ab}	2.43 ± 0.02^{b}	2.55 ± 0.01^{a}
TG (mmol/L)	10.22 ± 0.12^{a}	10.04 ± 0.09^{b}	9.97 ± 0.06^{b}	10.07 ± 0.03^{b}
Ca (mmol/L)	4.82 ± 0.11^{b}	4.79 ± 0.09^{b}	4.92 ± 0.06^{a}	4.94 ± 0.03^{a}
P (mmol/L)	2.39 ± 0.02^{c}	2.45 ± 0.06^{b}	2.57 ± 0.04^{a}	2.48 ± 0.05^{b}

Note: Different letters indicate a statistically significant difference.

Blood glucose is one of the most sensitive indexes to regulate the metabolism of substance and the change of blood glucose can reflect the absorption, translocation and metabolism of the body. Under the conditions of heat stress, the dietary fat powder can significantly reduce the blood glucose concentration. Our findings on the effects of dietary emulsified fat powder on decreasing the content of blood glucose are consistent with those of Chen et al. (2011) [8], who found an decreased blood glucose content feed with corn oil in the diet. Serum total protein, albumin and globulin were closely related to protein synthesis and metabolism in animals. The serum total protein is an effective index reflecting the protein metabolism, and its content reflects the nutritional status, growth and development, physiological status. The high content of serum total protein is a strong expression of protein metabolism in the body, which is beneficial to the absorption and utilization of the protein, and beneficial for improving the performance of animal production and reducing the feed consumption. In this study, the content of serum total protein was significantly increased by adding the emulsified fat powder, and the serum total protein content showed a linear increasing trend with the increase of the level of emulsified fat powder. These results showed that the emulsified fat powder could promote the digestion, absorption and utilization of protein. Serum albumin is one of the most abundant protein in the plasma of animals, maintaining the plasma osmotic pressure. Meanwhile, it is a source of body protein, tissue repair and providing energy, and an important indicator of liver function and nutritional status. Whitehead et al.[9]reported that supplemental fat increased the proportion of albumen at 32 wk of age. In this study, the content of serum albumin can be increased by the addition of the emulsified fat powder. Serum

globulin is an important index to reflect the immune function. The results of this study showed that the serum globulin contents of the emulsified fat powder groups were higher than that of the control group, which indicating that dietary emulsified fat powder could enhance the immune function of hens.

Serum urea nitrogen is a waste generated in the process of protein metabolism, which can accurately reflect the decomposition and metabolism of the body protein and the status of renal function. The results of this study showed that the dietary emulsified fat emulsion powder decreased the content of serum urea nitrogen, indicating that the body protein synthesis speed was greater than that of the decomposition rate, and improving protein synthesis efficiency. Serum levels of TC and TG are important biochemical indexes reflecting the normal lipid metabolism in animals. Under normal circumstances, the impact of these indicators were easily affected by the diet composition and body metabolism. The results of this study showed that tha addition of emulsified fat powder could reduce the content of serum TC and TG. The main reason may be the abundant content of unsaturated fatty acid in the emulsified fat powder, and the added emulsified fat powder inhibited the synthesis of fatty in liver, but the exogenous fatty utilization capacity was increased significantly.

Effect of the emulsified fat powder on antioxidant activity

Compared with the control group, the superoxide dismutase (SOD) activity of group I, II, and III were significantly increased by 0.97%, 3.29% and 2.80%, respectively; there was no significant difference between the group II and group III. The glutathione peroxidase (GSH-Px) activity of group I, II, and III were increased by 0.56%, 10.66%, 8.16%, respectively; among them the activity of group II was the highest, significantly higher than that of the control group and group I, but there was not significant difference compared with group III. The content of methane dicarboxylic aldehyde (MDA) in group III was lowest in the four groups, which was significantly lower than that of the control group and group I, but there was not significant difference between group III and group II.

Table 5 The effect of the emulsified fat powder on antioxidant activity

Item	*Control group*	*Group I (1%)*	*Group II (3%)*	*Group III (5%)*
SOD (U/ml)	221.16±1.78^{a}	223.28±3.45^{b}	228.46±2.46^{c}	227.33±1.25^{c}
GSH-Px (mU/ml)	1739.21±22.68^{a}	1748.46±11.99^{a}	1924.24±36.42^{b}	1880.67±27.12^{b}
MDA (nmol/ml)	8.23±0.13^{a}	8.02±0.22^{a}	7.29±0.19^{b}	7.06±0.14^{b}

Note: Different letters indicate a statistically significant difference.

Generally, the increase of SOD activity showed that the body's antioxidant capacity enhanced, and the decrease of MDA content showed that the degree of lipid peroxidation decreased. The SOD and GSH-Px are important components in the enzymatic antioxidant system, and playing the vital role between oxidation and anti-oxidation. The level of their activities can reflect the animal organism to scavenge free radicals ability. MDA is the end product formed by the oxidation of lipid peroxide (LPO), the level of its content can not only reflect the body LPO formation rate and intensity, but also can reflect the lipid by active oxygen free radicals attack damage. The results of this study showed that the dietary emulsion fat powder can improve serum SOD and GSH-Px activity, reduce the MDA content, but the activity of serum SOD and GSH-Px did not increase with the addition level increasing. There was downward trend in the content of serum MDA with the addition level of emulsified fat powder. These results suggested that the emulsified fat powder could enhance antioxidative function through increasing the activity of antioxidant enzymes activity and the inhibition of lipid peroxidation.

CONCLUSION

The dietary of the emulsified fat powder in laying hens can improve the laying rate and average egg weight, reduce the broken (soft) egg rate, but there was no effect on the rate of abnormal eggs; the emulsified fat powder can reduce the content of serum glucose and urea nitrogen, increase the content of serum total protein, albumin and globulin; the emulsified fat powder can improve the eggshell thickness and egg yolk color series, but there was no significant effect on egg shape index; the emulsified fat powder can reduce the content of serum TC and TG, and increase the content of serum Ca and P; the emulsified fat powder can improve serum SOD and GSH-Px the activity and decrease the content of MDA, improving the antioxidant performance of laying hens.

Acknowledgement

This work was financially supported by the Shandong Modern Agricultural Technology & Industry System, China (SDAIT-11-16).

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