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Effect of Dietary Soy Lecithin on Laying Performance, Egg Quality and Meat Texture of Aged Layer Hen

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ABSTRACT

This study was conducted to determine the laying performance, egg quality and meat texture of aged layer hens fed with soy lecithin. A total of 100 layer hens (Novogen Brown), aged 76-weeks old, were randomly assigned to five treatment groups and treated as follows: basal diet with 0% (control), 2%, 4%, 6% and 8% soy lecithin, respectively. After four weeks of treatment, lecithin showed no improvement in body weight gain, egg mass, egg production, feed intake, feed conversion efficiency, egg quality and meat texture . Meanwhile, egg weight increased in birds fed with 2% lecithin (P=0.02) and this might be attributed to the high linoleic acid content in soy lecithin. The results implied that feeding hens with 2% lecithin increased egg weight but it had no beneficial effects on other laying performance parameters. Thus, it is of interest to investigate potential benefits of lecithin on different dietary fat sources.

Keywords: Egg quality, layer hen, laying performance, lecithin, meat texture

INTRODUCTION

With increasing bird age, the rate of egg production reduces and the incidences of thin-shelled and cracked eggs markedly increase (Lillpers & Wilhelmson, 1993). Egg quality such as Haugh unit and egg weight were also negatively affected by increasing hen age (Akyurek & Okur, 2009). Consequently, the economic life of a bird is often as short as two years. Meanwhile,

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meat from spent layer hens (more than 1.5 years old) that have completed most of their egg production, is tougher, less acceptable by consumers and usually sold at a lower price than broiler meat (Kijowski, 1993). Tougher meat from older animals is a result of increased meat collagen content and collagen insolubility (Nakamura et al., 1975).

Soy lecithin is a by-product from the processing of soybean oil that contains a mixture of various phospholipids such as phosphatidylcholine (PC), phosphatidylethanolamine (PE) and phosphatidylinositol (PI). Phospholipids are components of cell membranes found in all living cells. Lecithins (E322) are commercially used as emulsifier and anti-oxidant in various food applications, cosmetics and pharmaceutical industries. Lecithin involved in regulating lipid metabolism (Huang et al., 2008). Lecithin was also reported to be an important source of choline in broiler diets (Pena et al., 2014). Lecithin is an omega-6 polyunsaturated fatty acid and contains high level of linoleic acid (Soares & Lopez-Bote, 2002). The ability of chicken to utilise dietary fat increases with age (Krogdahl, 1985; Tancharoenrata et al., 2013) and this is more pronounced in diets containing higher polyunsaturated fatty acids (Wiseman et al., 1991; Smits et al., 2000). Lecithin provides energy and it has been used as a substitute for dietary fats and oil to improve broiler productivity (Azman & Ciftci, 2004; Huang et al., 2007). Attia et al. (2009) demonstrated that 47-weeks old dual-purpose crossbred hens, fed with 3% soy lecithin as an extra energy source, had improved laying rate, egg weight and egg mass. Despite the impact of lecithin on providing energy, essential fatty acids and improving lipid metabolism, soy lecithin has received little attention in layer hen nutrition. Hence, this study aimed to investigate the effects of dietary soy lecithin on laying performance, egg quality and meat texture of aged layer hens.

MATERIALS AND METHODS

Animals and Management

A total of 100 Novogen Brown hens were obtained from a commercial pullet-rearing farm at the age of 75 weeks with an average weight of 2.0 ± 0.06 kg (mean ± s.e.d.). Upon arrival, hens were adapted to the experimental diet for one week. The birds were randomly allocated in individual battery pens and assigned to five treatment groups. Each treatment group consisted of five hens, and with four replicates. The dietary treatments included: (i) basal diet without soybean lecithin as control; (ii) soybean lecithin at 2%; (iii) soybean lecithin at 4%; (iv) soybean lecithin at 6%; and (v) soybean lecithin at 8% of basal diet. The composition of the test diets are as displayed in Table 1. Experimental diets were fed to the birds starting from 76 weeks old to slaughter at 80 weeks old. All the birds had *ad libitum* access to feed and water via nipple drinker prior to reaching an average final slaughter live weight of 2.0 ± 0.06 kg (mean ± s.e.d.).

Laying Performance

Egg production was recorded daily and hen-day egg production was calculated using formula [1].

$$\text{Hen-day egg production} = \frac{\text{Total number of eggs produced during the period}}{\text{Total number of hen-days in the same period}} \times 100 \quad [1]$$

Table 1
Formulation and calculated composition of diets

Item	0% soy lecithin	2% soy lecithin	4% soy lecithin	6% soy lecithin	8% soy lecithin
Ingredients (%)					
Corn	47.80	45.16	44.20	42.13	40.30
Soybean	22.00	21.20	21.85	27.10	28.43
Fish meal	4.36	4.90	4.62	1.23	0.51
Wheat pollard	10.65	12.65	12.24	10.50	10.18
Crude palm oil	3.70	2.76	1.65	0.92	0.04
Soy lecithin	0.00	2.00	4.00	6.00	8.00
DL-methionine	0.07	0.07	0.07	0.09	0.10
Dicalcium phosphate	0.68	0.53	0.60	1.31	1.45
Calcium carbonate	10.09	10.13	10.12	10.07	10.06
Choline chloride	0.03	0.03	0.03	0.03	0.32
Salt	0.30	0.25	0.30	0.30	0.29
Mineral premix[1]	0.05	0.05	0.05	0.05	0.05
Vitamin premix[2]	0.03	0.03	0.03	0.03	0.03
Antioxidant[3]	0.14	0.14	0.14	0.14	0.14
Toxin binder[4]	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Calculated analysis (g/kg)					
ME (kcal/kg)	2833	2830	2831	2830	2830
Crude protein	17.11	17.11	17.10	17.12	17.11
Crude fat	5.92	6.00	5.92	5.97	6.06
Crude fibre	3.60	3.64	3.62	3.77	3.79
Calcium	4.40	4.40	4.40	4.40	4.40
Phosphorus available	0.34	0.34	0.34	0.34	0.34
Methionine	0.38	0.38	0.38	0.38	0.38
Lysine	0.95	0.95	0.95	0.97	0.97

[1] Provided per kg of diet: Fe 120 mg; Mn 150 mg; Cu 15 mg; Zn 120 mg; I 1.5 mg; Se 0.3 mg; Co 0.4 mg.
[2] Provided per kg of diet: Vitamin A 11494 IU; vitamin D 1725 IU; vitamin E 40 IU; vitamin K3 2.29 mg; cobalamin 0.05 mg; thiamine 1.43 mg; riboflavin 3.44 mg; folic acid 0.56 mg; biotin 0.05 mg; panthothenic acid 6.46 mg; niacin 40.17 mg; pyridoxine 2.29 mg.
[3] Butylated hydroxyanisole
[4] Natural hydrated sodium calcium aluminium silicate
ME: Metabolisable energy

Feed intake was recorded by calculating the average daily feed intake of the five hens in each replicate on a weekly basis. Using one egg from each replicate, egg weight was determined once a week, regularly in the same day of week. Egg mass (g/bird per day) and feed conversion efficiency (feed intake/egg mass) were calculated every week throughout the experimental period.

Egg Quality

Egg quality was measured using one egg from each replicate collected on the last day of each week. Eggshell thickness was measured using a vernier caliper after being dried off at room temperature for three days. Haugh unit was determined using Egg Analyzer™ (SANOVO, Denmark). The yolk colour, height, thickness of egg white and the Haugh unit were automatically measured, calculated and recorded. Haugh unit values were calculated from egg weight (W) and albumen height (H), using the following formula:

Haugh unit
$= 100 \log (H\text{-}1.7W^{0.37}+7.6)$, as described by Eisen et al. (1962).

Meat Cooking Loss and Shear Force analysis

At the end of the experiment, all the birds were slaughtered by severing the jugular vein. *Pectoralis major* muscles were dissected from the carcass after chilling at 4°C for 24 hr. Cooking loss was measured according to the method of Honikel (1998). Samples were weighed and recorded as the initial weight ($W1$). Then, the samples were placed in individual polyethylene plastic bags and cooked in a pre-heated water bath set at 80°C. When the internal temperature reached 80°C, the cooking was continued for another 20 min. After that, the cooked samples were equilibrated to a room temperature for about an hour, removed from the bag, blotted dry using paper towels without squeezing, and ($W2$). Percentage of cooking loss was calculated as: $[(W1\text{-}W2)/W1]$ x 100. The samples used for cooking loss determination were used for determining meat tenderness. Strips [1cm (thickness) x 1cm (width) x 2 cm (length)] parallel to the muscle fibre were prepared and sheared perpendicular to the longitudinal direction of the fibres by Volodkevitch bite jaw attached to TA.HD plus® texture analyser (Stable Micro System, UK) (Nakyinsige et al., 2014). Shear force values were expressed as kilogram force (kg f).

Statistical Analysis

Data were analysed using one-way analysis of variance (ANOVA). All data were also analysed for linear and quadratic effects of soy lecithin supplementation using the Genstat software 13th ed. (VSN International Ltd, UK). Ninety five percentage level of confidence ($P<0.05$) was taken as significant.

RESULTS AND DISCUSSION

Laying performance, egg quality and meat quality data are as presented in Table 2. Lecithin showed no linear and quadratic effects on all the parameters measured ($P>0.05$, data not shown). In particular, lecithin had no effect on egg quality such as Haugh unit, yolk colour and shell thickness ($P>0.05$, respectively). Lecithin also had no effect on body weight gain, egg mass, egg production, feed intake and feed conversion efficiency ($P>0.05$, respectively). The laying performance results are in agreement with Attia et al*.* (2009), who were unable to find any changes in the laying performance of dual-purpose crossbred hens fed increasing levels of soy lecithin within the isocaloric diets. On the other hand, a study using broilers showed that diets containing soybean oil and soy lecithin mixtures in the proportion of 75/25 improved average daily gain and feed conversion efficiency (Huang et al., 2007). In a separate study using broilers, diets containing soybean oil and soy lecithin mixtures in the proportion of 75/25 increased daily weight gain in the grower period but feed conversion efficiency was not affected (Azman & Ciftci, 2004). Both studies in broilers showed that lecithin had no effect on the utilisation of lipid. It was indicated that a lower ration of saturated fatty acid to polyunsaturated fatty acid had a better feed conversion ratio (Wongsuthavas et al., 2008). Saturated fatty acids were proven to be less digestible than unsaturated fatty acids (Smink et al., 2008). Palm oil used in the current study is of vegetable origin but it is rich in saturated fatty acids, particularly palmitic acid (Smink et al., 2008). The high content of saturated fatty acids in the palm oil could have influenced the benefits of lecithin in improving body weight gain and feed conversion efficiency. The effects of lecithin on different fat sources still need further research. Broilers are selected for rapid growth and high meat yield whilst layer chickens for egg production. Consequently, the body weight gain of broiler is higher than those of layers at a similar age (Zhao et al., 2004). In commercial poultry production, peak production usually occurs when birds reach 24-26 weeks of age and production steadily declines until the flock is taken out of production at approximately 80 weeks of age. A decline in body weight gain at the end of the production cycle was expected because the hens were no longer in the development stage of life. It may be possible that body weight gain and feed conversion efficiency could be improved if lecithin supplementation was initiated during the growing period (8 to 18 weeks old).

Egg weight increased in birds fed 2% lecithin ($P=0.02$). Attia et al. (2009) reported that increasing levels of soy lecithin within the isocaloric diets did not affect the laying performance including egg weight. However, when 3% lecithin was used as an extra energy source, it increased laying rate, egg weight, egg mass and body weight gain, as well as improved feed conversion efficiency. This was suggested to be attributed to the increase in the availability of energy, essential fatty acids and choline, and lipid absorption. Choline bioavailability of de-oiled soy lecithin was estimated to be equivalent to choline chloride, a common source of choline in poultry diet (Emmert et al., 1996). These

Table 2
Effects of feeding five levels of soy lecithin to layer hens aged between 76 to 80 weeks old on laying performance, egg quality and meat texture

	Dietary soy lecithin (%)					s.e.d.	P value
	0	2	4	6	8		
Laying performance							
Body weight gain (g)	-14	58	-35	-34	-48	49.4	0.240
Egg weight (g/egg)	66.86[a]	76.34[b]	67.7[a]	66.32[a]	64.38[a]	2.332	0.020
Hen-day egg production (%)	68.13	75.79	67.7	67.06	69.85	5.403	0.497
Egg mass (g/hen/day)	98.43	110.95	107.03	98.87	96.6	9.084	0.475
Feed intake (g/hen/day)	115.5	119.0	116.9	113.9	109.3	5.79	0.546
Feed conversion efficiency	4.78	4.68	4.47	4.62	4.87	0.348	0.800
Meat quality							
Cooking loss (%)	27.48	27.91	27.38	28.28	27.69	0.852	0.838
Shear force (kgf)	0.92	1.12	1.08	1.24	1.08	0.138	0.233
Egg quality							
Haugh unit (mm)	51.14	50.24	62.17	60.01	55.08	6.927	0.378
Yolk colour	5.16	5.27	5.36	4.64	4.88	0.316	0.218
Shell thickness (mm)	0.29	0.30	0.29	0.28	0.30	0.016	0.549

s.e.d: standard error of difference
[a,b] Means with different superscripts differ significantly (P<0.05)

authors reported that supplementation of the choline-free purified basal diet with choline or de-oiled lecithin induced linear increases in feed intake and weight gain of broilers. To the authors' knowledge, no one has investigated the effects of dietary choline on laying performance of aged layer hen. Egg weight increased when linoleic acid was supplemented in the layer diets containing linoleic acid that was below the NRC requirements (Grobas et al., 1999). Laying hens do not need more than 1.0% of linoleic acid in their diet to maximise egg size (Pérez-Bonilla et al., 2011). Soy lecithin contains 83.98% of polyunsaturated fatty acid with linoleic acid being the dominant fatty acid (Huang et al., 2007). The high linoleic acid content in soy lecithin may contribute to the increased egg weight in birds fed with 2% lecithin in the current study. All the treatment groups lost weight except for hens fed with 2% lecithin (P>0.05), and this might explain the increased egg weight.

Cooked meat shear force values and cooking loss were not affected by lecithin (P>0.05, respectively) (Table 2). In contrast, Moraes et al. (1981) observed that soy lecithin supplementation in broiler chicken diet increased the toughness of dark meat, that was also proven to be tougher compared to white meat. Studies in pigs showed that soy lecithin supplementation had no effect on pork shear force values (D'Souza et al., 2012; Akit et al., 2014). Lecithin might influence meat texture if the treatment was started as early as the grower stage since maturity of collagen increases with age (D'Souza et al*.,* 2012).

In conclusion, 2% soy lecithin increased egg weight of aged layer hens. However, lecithin did not improve egg production, feed conversion efficiency, as well as egg quality and meat texture. Therefore, it is of interest to investigate potential benefits of lecithin on different dietary fat sources.

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