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Egg Production Performance of Old Laying Hen Fed Dietary Turmeric Powder

D. P. Rahardja, M. Rahman Hakim, V. Sri Lestari

***Abstract*—**An experiment was conducted to elucidate the effects of turmeric powder supplementation on egg production performance of old laying hens (80 weeks of age). There were 40 hens of Hysex Brown strain used in the study. They were caged individually, and randomly divided into 4 treatment groups of diet containing 0 (control), 1, 2 and 4 % oven dried turmeric powder for 3 periods of 4 weeks; Egg production (% hen day) and feed intake of the 4 treatment groups at the commencement of the experiment were not significantly different. In addition to egg production performance (% and egg weight), feed and water intakes were measured daily, and cholesterol content of the whole egg was determined. The results indicated that feed intakes of the hen were significantly lowered when 4% turmeric powder supplemented, while there were no significant changes in water intakes. Egg production were significantly increased and maintained at a higher level by turmeric powder supplementation up to 4% compared with the control, while the weight of eggs were not significantly affected. The research markedly demonstrated that supplementation of turmeric powder up to 4% could improve and maintain egg production performance of the old laying hen at a higher level with a lower cholesterol content.

***Keywords*—**Curcumin, feed and water intake, old laying hen, egg production.

I. Introduction

CURCUMA longa L. is a perennial herb belongs to the family of *Zingiberaceae*, distributed throughout tropical and subtropical regions of the world [1]. In Indonesia, the rhizome is known as kunyit or (turmeric) used as traditional remedy and usually mixed with other herbs for various biological activities, which traditionally called "jamu". Curcuminoid is the main compound of the turmeric; in which curcumin is the major component comprises the phenolic yellowish pigment. Curcumin has been shown to have a wide spectrum of biological actions. These include its anti-inflammatory, antioxidant, anticarcinogenic, anti- mutagenic, anticoagulant, antifertility, antidiabetic, anti-bacterial, antifungal, antiprotozoal, antiviral, antifibrotic, anti-venom, antiulcer, hypotensive, hypocholesteremic and hepatoprotective activities [1]-[5]. Basically, egg production is determined by the rate of ovulation and developing follicles in the ovary, and laying period; Ovulation rate of follicles are determined by deposition of the yolk components into the development follicle, and it depend on the liver function in which most of the components are synthesized. There is an indication that liver function decreases with an increase in age and with an advance in egg production. On the other hands, curcumin modulates and speeds up the process of repair or regeneration of liver cells [6]. It is, therefore, this experiment was designed to investigate the efficacy of different levels of turmeric powder supplementation on egg production performance of old laying Hen.

D. P. Rahardja is with the Animal Physiology Laboratory, Animal Science Faculty, University of Hasanuddin – Makassar, 90245 South Sulawesi, Indonesia (corresponding author e-mail : djonipra@gmail.com).

M. Rahman Hakim is with the Poultry Production Laboratory, Faculty of Animal Science, University of Hasanuddin – Makassar, 90245 South Sulawesi, Indonesia.

V. Sri Lestari is with the Dept. Socio Economy - Faculty of Animal Science, University of Hasanuddin – Makassar, 90245 South Sulawesi, Indonesia.

II. Materials and Methods

The experiment was arranged as a completely randomized design using 40 laying hens of Hysex Brown, aged 80 weeks at the commencement of the experiment; they were placed randomly in individual cages having water and food vessels. Each group was divided into 4 treatment groups of 10 hens as replication for the treatments of 0 (control), 1, 2 and 4% Turmeric powder supplementation of basal diet, and the experiment was conducted for 3 period of 4 weeks; Average daily egg production of each treatment group at the commencement of the experiment were 77.14, 74.29, 76.01 and 73.16% respectively. In accordance with the standard procedures, nutrient contents of basal diet were 91% dry matter, 17% protein, 5.1% Fat, 2.3% fiber, and 2800 kcal energy/kg. Turmeric rhizome was purchased from a certain shop of a traditional market in Makassar. There was no information about the origin and harvesting time of Turmeric rhizome purchased. Fresh Turmeric rhizome were peeled and cut into thin pieces. Then, it was subsequently spread on a hot air oven tray at 55-60°C. Drying process was continued for 20-24 h to ensure the appropriate consistency for grinding to make a powder form. Diets were prepared the following day and were stored at room temperature for a maximum of 1 week. Thin Layer Chromatography (TLC) was used to determine Curcumin (diferuloylmethane) content of the rhizome, which is 2.85 ppm, or 3.2% and composes curcumin I (± 94%), curcumin II (± 5.4%) and curcumin III (0.6%).Food and water were provided ad libitum, and daily intakes, and egg production of individual hens were recorded; Egg production (%) was calculated monthly. At the last day of each period, there were 3 eggs sampled from each experimental unit for analyzing cholesterol content of the whole egg (egg weight x cholesterol concentration) which was determined by Liebermann Burchard procedure [7]. Data were statistically analyzed in accordance with 2 ways analysis of variance (4 levels of turmeric supplementation x 3 trial periods as repeated measure). When the F test indicated a significant effect, the

differences between the mean values were analyzed by the procedures of Duncan multiple range test [8].

TABLE I
FEED AND WATER INTAKES OF LAYING HENS HISEX BROWN BEFORE AND AFTER FED DIETARY TURMERIC POWDER

Before Treatment	% Turmeric Powder	Period 1	Period 2	Period 3	Mean
		Feed intake (g/d)			
132.72 ± 3.09 [a]	Control	135.75 ± 3.10 [a]	133.07 ± 4.06 [a]	136.32 ± 9.99 [a]	135.05 ± 8.12 [a]
133.32 ± 6.73 [a]	1	137.61 ± 3.62 [a]	135.09 ± 7.53 [a]	135.01 ± 6.53 [a]	135.09 ± 6.73 [a]
137.50 ± 9.62 [a]	2	131,79 ± 4.63[a]	128.61 ± 9.20 [a]	128.79 ± 9.06 [a]	129.73 ± 7.73 [a]
131.75 ± 8.59 [a]	4	117.36 ± 6.42 [b]	116.75 ± 4.49 [b]	116.96 ± 5.57 [b]	117.02 ± 6.76 [b]
		Water intake (ml/d)			
333.57 ± 3.03 [a]	Control	330.14 ± 13.05 [a]	337.86 ± 8.67 [a]	327.83 ± 6.28 [a]	331.94 ± 12.12 [a]
342.00 ± 2.02 [a]	1	331.15 ± 15.28 [a]	338.76 ± 11.85 [a]	329.78 ± 7.05 [a]	333.23 ± 10.73 [a]
339.64 ± 4.55 [a]	2	338.81 ± 7.24[a]	335.07 ± 16.74 [a]	328.29 ± 4.31 [a]	334.05 ± 10.73 [a]
336.07 ± 5.56 [a]	4	335.64 ± 8.63 [a]	334.02 ± 6.71 [a]	329.58 ± 5.47 [a]	333.13 ± 6.76 [a]

Mean values with different superscripts in the same column indicate differ significantly ($P<0.05$)

III. RESULT AND DISCUSSION

The results (Table I) showed that turmeric powder supplementation up to 2% did not significantly affect feed intake, but increasing supplementation to 4% resulted in a significant lower in feed intake, while water intakes were not significantly affected by turmeric powder supplementation.

These results may apparently be attributed to: (1) palatability of the ration since the 1st period; a similar trend is also indicated by 2% turmeric supplementation since the 2nd and the 3rd periods of the treatment. Moreover, it may also be attributable to (2) glucostatic theory of feed intake, as curcumin has a similar effect with insulin in controlling homeostasis of blood glucose [3], [9]-[11], and to (3) its chemical composition which mostly contains carbohydrate (69.4%) [2]. In addition to phenolic and terpenoid compounds [1], [5]. In relation to water intake, there is an indication that increasing supplementation of turmeric powder from 0, 1, 2 to 4% in the ration, required an increase in water intake, which are from 245.79, 246.6, 257.49 to 284.68 ml water per 100 g of feed intake respectively.

Turmeric powder supplementation up to 4 % in the ration of old laying hen showed a significant effect to improve egg production, but did not significant on egg weight (gr/egg) (Table II). The improved egg production performance was apparently maintained by turmeric supplementation along the 3 periods of experiment, while it was gradually decreased by the control hen, without a significant alteration in egg weight, as well as yolk index, egg shell index and Haugh unit (unpublished data).It is an indication that the quality of egg produced by old laying hen fed dietary turmeric powder was maintained regardless of the percentages and periods of supplementation.

Cholesterol contents in the egg produced by old laying hens (Table III) fed dietary turmeric powder was significantly decreased, and the decreases were maintained along the experiment.

The results of this experiment confirmed that turmeric powder supplementation could improve hepatocytes functions. This implies that the effects of curcumin in turmeric powder not only improves liver disorders or damage [12], [13] but also protect and prevent liver damage with the advance of age and egg production in fowls, and it was also reported in rats [14]-[16].

Turmeric powder also contains flavonoids that act as phytoestrogen which have estrogen-like activity, improving hepatocyte functions and activities, then improve vitellogenin synthesis during egg laying period. Vitellogenin, an egg yolk protein precursor, is synthesized in parenchymal hepatic cells in response to oestrogen, containing about 20% fat, mainly phospholipids, triglycerides, lipoprotein, and cholesterol, which are packaged in the form of VLDL (Very Low Density) and this VLDL has a half size of the normal VLDL and its surface binds to a polipoprotein VLDL-II [17]-[19]; An experiment on laying quail [20] demonstrated that turmeric powder supplementation improved liver function, which is particularly attributed with total number of liver cell per weight of tissue, and therefore the total capacity of the liver tissue to synthesize the substrates for yolk deposition; These results were supported by increasing vitellogenin synthesis by the liver cells as a precursor for egg yolk deposition in the developing follicle, secreted into the blood. It could be attributed with increasing processes folliculogenesis and ovogenesis then resulted in increasing amount of the developing follicles in the ovary, which reflected in increasing egg production performance. The decreased cholesterol content in the egg produced by old laying hen fed dietary turmeric powder, in part, might be due to the increased number of developing follicles. With the greater number of developing follicles, cholesterol and fat as the main component of the yolk will be distributed to a greater number of growing follicles, so that the content of cholesterol and fat in each egg will be lower.

There was assumed that active compound of turmeric powder, curcumin stimulate hepatocyte growth and decrease hepatocyte destruction. This bioactive compound in turmeric powder has anti-hepatoxic effect, as the nature of the compound that inhibits lipid peroxidation in the cell membrane and protects hepatocytes by inhibiting NF-kappa-β, pro-inflammatory cytokines production and oxidative stress [15], prevents and reverses cirrhosis [16] in rats. Curcumin

acts as a free radical scavengers, inhibits the generation of reactive oxygen species such as superoxide anion, H_2O_2, nitrite radicals by activating macrophages that play an important role in the inflammatory process [21].

TABLE II
EGG PRODUCTION AND EGG WEIGHT OF LAYING HENS HISEX BROWN BEFORE AND AFTER FED DIETARY TURMERIC POWDER

Before treatment	% Turmeric powder	Period 1	Period 2	Period 3	Mean
Egg Production (%)					
77.14 ± 5.37[a]	Control	71.43 ± 5.29[a]	69.84 ± 5.78[a]	65.71 ± 4.43[a]	68.99 ± 4.82 [a]
74.29 ± 5.65 [a]	1	78.86 ± 7.95 [b]	79.83 ± 8.63 [b]	79.86 ± 4.52 [b]	79.52 ± 6.53 [b]
76.54 ± 6.63 [a]	2	77.54 ± 9.15 [b]	78.73 ± 6.29 [b]	77.70 ± 4,52 [b]	77.99 ± 6.93 [b]
73.16 ± 6.22 [a]	4	78.57 ± 6.39 [b]	77.65 ± 8.13 [b]	76.57 ± 9.04 [b]	77.59 ± 7.05 [b]
Egg weight (g/egg)					
57.98 ± 4.01[a]	Control	59.89 ± 4.99 [a]	60.38 ± 4.66[a]	60.66 ± 4.67 [a]	60.31 ± 4.21 [a]
59.22 ± 4.82 [a]	1	59.40 ± 2.50[a]	59.52 ± 1.56[a]	60.53 ± 4.57[a]	59.82 ± 3.32 [a]
58.25 ± 3.57 [a]	2	58.71 ± 3.46[a]	59.87 ± 1.62[a]	60.32± 3.53 [a]	59.63 ± 2.43 [a]
60.19 ± 3.83[a]	4	60.61 ± 2.40[a]	60.36 ± 2.58[a]	61.94 ± 2.28[a]	60.97 ± 2.31 [a]

Mean values with different superscripts in the same column indicate differ significantly (P<0.05)

TABLE III
CHOLESTEROL CONTENT OF EGG PRODUCED BY OLD LAYING HENS OF HISEX BROWN BEFORE AND AFTER FED DIETARY TURMERIC POWDER (MG/EGG)

Before treatment	% Turmeric powder	Period 1	Period 2	Period 3	Mean	- / + (%)
318.72 ± 12.73 [a]	Control	329.21 ± 14.37 [a]	327.10 ± 18.77 [a]	326.93 ± 23.47 [a]	327.77	+ 6.16
300.44 ± 10.58[a]	1	251.07 ± 8.76[b]	256.76 ± 19.77[b]	249.93 ± 16.82[b]	252.59	- 15.93
305.62 ± 8,75[a]	2	243.35 ± 18,79[b]	221.28 ± 15,07[b]	227.16 ± 17.65[b]	230.60	- 24.55
314.63 ± 13.73[a]	4	244.36 ± 16.74[b]	235.33 ± 11.54[b]	226.24 ± 13.54[b]	235.31	- 25.21

Mean values with different superscripts in the same column indicate differ significantly (P<0.05)

Curcumin has antioxidant activity by inhibiting the activity of inflammatory enzymes or by increasing the synthesis of glutathione [22]. As a hepatocyte growth factor [12], curcumin stimulates hepatocyte growth and development and as a hepatoprotector agent protects the integrity of the hepatocytes and modulate the growth and cellular responses [23] and to recure the acute liver cell damage by CCl4 [15], [16]. Therefore, there was a possibility that old laying hen fed dietary 4% turmeric powder could maintain egg production performance (Table II) even though their feed intakes (Table I) were lower compared with the other groups of treatment, including control.

Liver and ovary are the primary organs of cholesterol synthesis in laying hen. However, there is little, if any, direct transfer of ovarian synthesized cholesterol to develop oocyte [24], [25]. Thus, the contribution of the ovaries on egg cholesterol levels is minimal. In contrast, cholesterol is readily transferred from the blood across the ovarian membranes to develop ova. Therefore most egg yolk cholesterol, if not all, originates from blood cholesterol. In this experiment, reducing egg cholesterol content may apparently be attributable with decreasing blood cholesterol concentration. The results indicated that cholesterol content (Table III) of the egg produced by the control group tended to increase up to 6% with an advance age, while it was decreased up to 16, 24 and 25 % by those of 1, 2 and 4% turmeric supplementation groups respectively regardless of age. An experiment on rat fed dietary curcumin [26] was to reduce serum triglyceride (TG) by 27%, total cholesterol by 33.8%, and LDL-cholesterol by 56%, respectively as compared to control group.

Although the mechanism is not completely understood yet, our experiment indicated clearly that turmeric powder has 'cholesterol lowering effect' on egg produced by old laying hen.

Accumulating evidence has indicated the hypocholesterolemic properties of curcumin, the yellow pigment in curry from turmeric, in animal models. Basically, the levels of plasma cholesterol are influenced by absorption in the gut, de novo biosynthesis, and the removal of cholesterol from the blood.

The intestine plays a major role in regulating cholesterol homeostasis and about 36% reductions of plasma cholesterol could be achieved by total inhibition of cholesterol absorption [27].Absorption of cholesterol is a multi-step process in which cholesterol is micellized by bile acids in the intestinal lumen, taken up by the enterocytes, assembled into lipoproteins, and transported to the lymph vessel and the circulation. Niemann-Pick C1-like 1(NPC1L1) protein has been identified as a specific transporter for cholesterol uptake at the surface of plasma membrane of the intestinal cells [28]. An experiment of tracer study showed that curcumin inhibits cholesterol uptake through suppression of NPC1L1 gene expression in the intestinal cells [29].

Curcumin attenuates diet-induced hypercholesterolemia by increasing the rate of cholesterol catabolism through conversion of cholesterol to bile acids in the liver, then increasing fecal excretion; the conversion will be enhanced in order to replenish the loss in bile acids [30], [31]; the conversion of cholesterol to bile acids is the major pathway of cholesterol elimination and accounts for about 50% of daily

cholesterol excretion [32]; Curcumin supplementation increased Cholesterol 7a-hydroxylase (CYP7A1) which is a liver-specific enzyme that catalyzes the rate-limiting step in the biosynthesis of bile acid from cholesterol in the liver [26]; Moreover, as a feed-back mechanism, effect of curcumin on enterocytes will inhibit reabsorption of excreted cholesterol as bile acids from digestive tract.

Overall, increasing in hepatic CYP7A1 gene expression and suppressing of NPC1L1 gene expression in the intestinal cells are the mechanism that partially accounts for the hypocholesterolemic effect of curcumin, and involve in cholesterol homeostasis [29], [33].

In addition, curcumin inhibits LDL oxidation [34]; inhibits Hepatic stellate cells (HSCs) activation by reducing cell proliferation, inducing apoptosis and suppressing gene expression of extracellular matrix (ECM) components in HSCs *in vitro* [35], [36]. Further studies reveal that curcumin induces gene expression of peroxisome proliferator-activated receptor-g (PPARg) [35], interrupting signalling cascades for platelet-derived growth factor (PDGF) and epidermal growth factor (EGF) [37]; transforming growth factor-beta (TGF-b) [35]; attenuating oxidative stress in activated HSCs [38]. This phytochemical protects the liver from injury and fibrogenesis in animal models [39]-[42].

Egg protein is a combination of protein contained in egg yolk and albumen. Albumen is a protein which is synthesized, excreted, and accumulated in the epithelial cells and tubulargland cells in the magnum of the reproductive tract. Even though egg protein contents were not measured in the experiment, there is a possibility effect of turmeric powder on protein synthesized by the reproductive tract. Result of an experiment on quail [43] showed that turmeric supplementation at dosage of 54 mg/quail/day resulted in increased egg protein content by 4.27%.

Taken together, it can be concluded that egg production performance of old laying hen fed dietary turmeric powder could be markedly improved to and maintained at a higher level for a longer production period with a lower content of cholesterol.

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