

Egg Production and Physical Quality in *Cortunix cortunix japonica* Fed Diet Containing Piperine as Phytogetic Feed Additive

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ABSTRACT

The objective of this study was to determine the effect of piperine as a phytogetic feed additive on quail performances and egg quality. The experiment used a completely randomized design with five treatments and four replications and used ten quails with one week of age in each replication. The piperine was added to the diets at concentrations of 0 (T0), 15 (T1), 30 (T2), 45 (T3), and 60 mg/kg body weight (T4) for 8 consecutive weeks. The results showed that addition of 60 mg/kg body weight (T4) of piperine significantly ($P<0.05$) reduced feed consumption, egg production, egg mass, income over feed cost (IOFC), and increased water consumption as compared to the other treatments. The addition of 15-60 mg piperine/kg body weight significantly ($P<0.05$) reduced eggshell weight and increased egg yolk color score. The conclusion of this experiment was that the addition of piperine at 15-45 mg/kg body weight could be used as phytogetic feed additive to improve performance, IOFC, haugh unit, and yolk color.

Key words: egg, feed additive, phytogetic, piperine, quail

ABSTRAK

Tujuan penelitian ini adalah untuk mengevaluasi efek piperin sebagai *phytogetic feed additive* pada performa produksi dan kualitas telur pada burung puyuh. Penelitian ini menggunakan rancangan acak lengkap dengan lima perlakuan dan empat ulangan dengan sepuluh puyuh tiap ulangan. Piperin ditambahkan ke dalam pakan basal dengan konsentrasi masing-masing 0 (T0), 15 (T1), 30 (T2), 45 (T3), dan 60 mg/kg bobot badan (T4) selama 8 minggu. Hasil penelitian menunjukkan bahwa penambahan piperin 60 mg/kg bobot badan (T4) sangat nyata ($P<0,05$) menurunkan konsumsi ransum, produksi telur, massa telur, *income over feed cost* (IOFC), dan meningkatkan konsumsi air dibandingkan dengan perlakuan lainnya. Penambahan piperin 15-60 mg/kg bobot badan nyata ($P<0,05$) menurunkan bobot kerabang telur dan meningkatkan warna kuning telur. Kesimpulan yang dapat diambil adalah penambahan piperin 15-45 mg/kg bobot badan dapat digunakan sebagai *phytogetic feed additive* untuk meningkatkan performa, IOFC, *haugh unit*, dan skor warna kuning telur.

Kata kunci: telur, pakan tambahan, fitogenik, piperin, puyuh

INTRODUCTION

Quail is one of the poultry that should be developed and enhanced its production potential because this species has a very short live cycle and efficient to produce animal protein needed in the form of eggs and meat for the community. According to BPS (2013), population of quails in Indonesia from 2009 to 2013 increased from 7,667,586 to 12,596,043 heads. There are some

advantages in business of quail such as the species starts laying egg at the age of six weeks, does not require large capital, easy on maintenance and need a smaller land area to rear the quails. However, to produce the production and good quality of eggs, many farmers use synthetic antibiotics in the feed causing antibiotics residues in the eggs and meat. According to Saeid & Al-Nasry (2010), food safety issues occurring in society, some of those are originally from animals include contamination of microbial pathogens and antibiotic residues in meat and eggs as a side effect of antibiotics in the feed that serves as Antibiotic Growth Promoters (AGPS).

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The measure taken to anticipate that issue was the use of phytogetic feed additive. Phytogetic feed additive is an additional material for feed that was derived from plants drug (herb) and spices as the replacement of antibiotic growth promoters (Lee *et al.*, 2013; Saki *et al.*, 2014), which is able to improve performance, feed conversion ratio, digestibility, and weight gain in poultry (Perić *et al.*, 2009; Saki *et al.*, 2014). One of the potential phytogetic feed additives is black pepper (*Piper nigrum*).

One of the active components contained in black pepper (*P. nigrum*) is piperine. Piperine is an alkaloid substance which can increase the absorption of selenium, vitamin B complex, beta-carotene, and curcumin as well as other nutrients (Khalaf *et al.*, 2008) that eventually improve performance, productivity, and carcass quality and increase the body's immune status (Cardoso *et al.*, 2012; Ravindran & Kallapurackal, 2012).

Piperine is also an active ingredient which works to increase thermogenesis in the body (Bhutani *et al.*, 2009; Ahmad *et al.*, 2012), increases digestion and energy metabolism in the body and increases the bioavailability of certain drugs in the organism (Ahmad *et al.*, 2012) so as to improve immunity. Cardoso *et al.* (2012) suggested that supplementation of piperine into the feed at the dosage of 60 mg/kg BW could increase performance and health status of broilers. The aim of this study was to determine the effectiveness of piperine as a phytogetic feed additive on production and egg's physical quality in *Coturnix coturnix japonica*.

MATERIALS AND METHODS

The black pepper (*P. nigrum*) was obtained from the farmers at Sukadana, Lampung Province. The black pepper was dried in the oven with a temperature of 60°C for 24 h and then grounded to be a powder. The content of phytochemical of the powder was 5.18% piperine (Balitro, 2014). According to Madhavi *et al.* (2009), the content of piperine in the black pepper is 5%-9% of the total nutrient.

The feeding trial in this experiment used 200 laying quails with 6 weeks of age and the average weight of 101.8 g/bird. Piperine doses calculation was based on a standard requirement of quail per day i.e., feed consumption of 25 g. Piperine content in black pepper is 5.18% so that each treatment dose was obtained as follows 15 mg/kg body weight: 1.18 g piperine/kg feed, 30 mg/kg body weight: 2.36 g piperine/kg feed, 45 mg/kg body weight: 3.54 g piperine/kg feed, and 60 mg/kg body weight: 4.72 g piperine/kg feed.

The experiment used a completely randomized design with five treatments and four replications with ten quails of each replication. The experimental quails were placed in 60 x 60 x 40 cm pen. The treatment diets were T0: Control diet (without piperine), T1: T0 + piperin 15 mg/kg body weight, T2: T0 + piperin 30 mg/kg body weight, T3: T0 + piperin 45 mg/kg body weight, T4: T0 + piperin 60 mg/kg body weight. The diet were formulated according to the nutrients requirement recommendation of Leeson & Summers (2005). The diet contained 18% crude protein and 2950 kcal/kg. Composition and

nutrients content of the control diet are presented in Table 1.

Quails were reared for 10 wk, 1 wk for environmental adaptation, 1 week for diet treatment adaptation, and 8 wk for diet treatment. Feed and water were provided *ad libitum*. Feed consumption and water consumption were measured every week, while egg production and egg weight were recorded every day during the treatment. Physical quality of egg was observed at the first, second, third, fourth, and eighth week of the treatment. Three eggs were taken from each replication for physical quality analysis. Parameters observed in this study were quail performance: feed consumption, water consumption, quail day egg production, egg mass, feed conversion, income over feed cost (IOFC), and egg physical quality.

All data were analyzed by using one way analysis of variance (ANOVA) according to General Linear Models (GLM) procedure for completely randomized design using SAS 9.3 (SAS, 2010). If there was a significant different, the data was further analyzed by using Duncan's multiple range test (Mattjik & Sumertajaya, 2006).

Table 1. Composition and nutrient contents of basal diet used in the experiment

Ingredients	(%)
Maize	58.40
Soybean meal	22.00
Fish meal	4.50
Rice bran	1.20
Corn gluten meal (CGM)	2.80
Palm oil	2.65
Di-calcium phosphate (DCP)	0.99
Calcium carbonate (CaCO ₃)	6.70
NaCl	0.30
Premix ¹	0.30
DL-Methionine	0.16
Total	100.00
Nutrient content ² (as fed)	
ME (kcal/kg)	2951.75
Crude protein (%)	18.03
Crude fat (%)	5.20
Crude fiber (%)	2.38
Methionine (%)	0.52
Lysine (%)	1.09
Methionine + Cystine (%)	0.84
Ca (%)	3.11
P available (%)	0.53
Na (%)	0.18

Note: ¹Premix composition each 10 kg contains vitamin A= 12,000,000 IU, vitamin D3= 2,000,000 IU, vitamin E= 8,000 IU, vitamin K= 2,000 mg, vitamin B1= 2,000 mg, vitamin B2= 500 mg, vitamin B6, vitamin B12= 12,000 g, vitamin C= 25,000 mg, Calcium-D-anthothenate: 6,000 mg, Niacin= 40,000 mg, Choline chloride= 10,000 mg, Lysine= 30,000 mg, Manganese= 120,000 mg, Iron= 20,000 mg, Iodine= 200 mg, Zinc= 100,000 mg, Cobalt= 200 mg, Copper= 4,000 mg, Zinc Bacitracin= 21,000 mg.

² Formulated based on nutrient requirement recommendations by Leeson & Summers (2005).

RESULTS AND DISCUSSION

Quail Performances

Supplementation of piperine with the dose of 60 mg/kg BW (T4) significantly ($P<0.05$) decreased feed consumption and increased water consumption compared to the other treatments (Table 2). Water consumption of control (T0) quail was lower ($P<0.05$) as compared to the other treatments. The decrease in feed consumption of T4 was due to a strong and spicy flavor that could reduce the palatability of the feed. Windisch *et al.* (2008) stated that the content of the active substances contained in black pepper caused the feed was very pungent and spicy flavor which may limit its use for animal feed. According to Amad *et al.* (2011), the addition of phyto-genic feed additive derived from spices could affect the flavor, such as piperine (spicy flavor) from phyto-genic compounds so that feed consumption would decline. The decreased feed consumption will have an impact on increasing water consumption due to the high content of piperine in the feed. The high content of piperine in the feed could trigger the process of thermogenesis in the body so that it will have an impact on increasing water consumption. The increased water consumption will increase the release of heat loss from the body. According to Boschmann *et al.* (2007), consumption of large amounts of water increase heat loss so that the release of the heat generated by the process of thermogenesis would be able to balance the body temperature.

Adding piperine as much as 15-45 mg/kg BW did not affect the egg production (quail day production). Adding piperine with the dosage of 30 mg/kg BW increased egg production significantly ($P<0.05$) compared to T4 but not significantly different from T0, T1, and T3. Egg production in quails supplemented with piperine with a dosage of 60 mg/kg BW (T4) was significantly ($P<0.05$) lower than the other treatments. The decreased egg production was due to the low feed consumption which affected the consumption of nutrients. According to Leeson & Summers (2005), egg production was affected by the strain, age, feed consumption, water consumption, the consumption of mineral, and protein content of feed, while Widjastuti & Kartasudjana (2006) explained that the low feed and energy consumption

during the production phase of quail would decrease egg production.

The average of egg mass in this study was 409.23-531.96 g/quail. Supplementation of piperine at the level of 15% up to 45% did not affect egg mass. Addition of piperine at the dose of 60 mg/kg BW (T4) decreased the egg mass significantly ($P<0.05$) compared to the other treatments. The decreased egg mass was due to the decrease in percentage of egg production that finally decreased egg mass. In contrast to results of the study conducted by Al-Harathi *et al.* (2009), the addition of spices such as black pepper, cumin, and cardomon could increase the egg mass and egg weight. The egg mass would be positively correlated with the decrease in egg production, while egg mass was calculated as the mean of egg weight produced by mean of laying rate during the production days so that would be positively correlated (Sh *et al.*, 2013). Furthermore Vercese *et al.* (2012) stated that the mass of egg was influenced by egg weight, egg production, and heat stress.

The treatments did not affect the feed conversion. The average feed conversion in this study was 2.10-2.41 (Table 2). Feed conversion in quails supplemented piperine with a dose of 60 mg/kg BW (T4) was significantly ($P<0.05$) lower than the other treatments. This lower feed conversion was due to the lower feed consumption with the higher weight of the eggs produced. Feed conversion values closely associated with the ability to change the feed into meat and eggs. The lower the figure the more efficient is the conversion of feed, since the amount of feed used to produce meat and egg is lower. According to Leeson & Summers (2005), the factors affecting feed conversion was egg production, nutrient content of feed, egg weight, and temperature.

Supplementation of piperine at the doses of 15 up to 45 mg/kg BW did not affect IOFC. Addition of piperine at a dose of 30 mg/kg BW (T2) increased IOFC significantly ($P<0.05$) compared to T4 but did not different significantly as compared to T0, T1, and T3. IOFC in quails supplemented with piperine at a dose of 60 mg/kg BW was significantly ($P<0.05$) lower than other treatments. Declining value of IOFC in the addition of piperine at a dose of 60 mg/kg BW was caused by the decrease of egg production and egg mass that impaired the income (Safingi *et al.*, 2013). Furthermore, Muslim *et al.* (2012) explained that the low value of IOFC was

Table 2. The average of feed consumption, water consumption, egg production, and feed conversion of laying quail during 8 weeks treatment

Variables	Treatments				
	T0	T1	T2	T3	T4
Feed consumption (g/quail/d)	19.94± 0.61 ^a	19.99±0.66 ^a	19.40± 0.65 ^a	19.49± 0.49 ^a	18.49± 0.44 ^b
Water consumption (mL/quail/d)	52.23± 6.96 ^c	62.94±5.33 ^b	68.28± 5.44 ^b	60.27± 4.65 ^b	80.16± 5.33 ^a
Egg production (%)	58.78± 2.72 ^a	59.04±1.79 ^a	59.57± 1.92 ^a	55.76± 4.74 ^a	45.05± 2.07 ^b
Egg mass (g/quail)	524.80±27.32 ^a	531.96±6.31 ^a	521.23±16.42 ^a	511.58±37.49 ^a	409.23±24.42 ^b
Feed conversion	2.41± 0.39	2.21±0.12	2.24± 0.08	2.10± 0.15	2.06± 0.09
IOFC (Rp/egg)	158.31±11.89 ^a	159.41±8.18 ^a	165.96± 7.65 ^a	146.33±22.61 ^a	99.50± 6.97 ^b

Note: T0= Control diet (without piperine), T1= T0 + piperine 15 mg/kg BW, T2= T0 + piperine 30 mg/kg BW, T3= T0 + piperine 45 mg/kg BW, T4= T0 + piperine 60 mg/kg BW. Means in the same row with different superscripts differ significantly ($P<0.05$).

influenced by the increased of feed intake and the decreased of egg production and egg mass.

Physical Quality of Egg

The supplementation of laying quails with piperine as a phytogetic feed additive did not affect egg weight. The average of egg weight was 8.97 g/egg. This results is in accordance with the standard weight of quail egg recommended by Tserveni-Goussi & Fortomaris (2011) and it ranges from 6 to 16 g/egg. The factors affecting egg weight is protein consumption (Tuleun & Adenkola, 2013), hormones (Latifa, 2007), and age (Tserveni-Goussi & Fortomaris, 2011). Furthermore Leeson & Summers (2005) states that protein or amino acid is a nutrient that plays an important role in controlling the egg weight.

The average of albumens weight was 5.29 g (55.99%), which showed that supplementation of piperine as a phytogetic feed additive did not affect albumen weight. Albumen weight is generally influenced by egg weight, age, genetic (Zita *et al.*, 2009), and hormones (Latifa, 2007). The average of albumens weight in this research were lower than reported by Tserveni-Goussi & Fortomaris (2011) that albumen weight was 7.80 g (56.83%). The percentage of normal quail egg albumen ranged between 60%-63% of the egg weight (Li-Chan & Kim, 2007) or 52%-62% of the egg weight (Nys & Guyot, 2011).

The supplementation of piperine as a phytogetic feed additive did not affect the yolk weight. The average of yolk weight was 3.07 g (32.09%) (Table 3). The averages of yolk weights in this research were lower than reported by Kumari *et al.* (2008) that yolk weight was 4.74 g (34.61%). According to Reyes-Herrera & Donoghue (2012), the yolk percentage is around 30%-32% of egg weight. As proposed by Darmawan *et al.* (2013), egg size was more related to the size of the yolk compared with albumen, despite the fact that albumen was still important to determine the size of an egg. According to Subekti *et al.* (2006), the decreased of yolk cholesterol levels could decrease yolk weight. Percentage of yolk ranged between 28% and 29% of the egg weight (Li-Chan & Kim, 2007), meanwhile according to Nys

& Guyot (2011) the range was between 30% and 33%. According to Zita *et al.* (2013), yolk weight was influenced by genotype and age as well as the cholesterol.

Supplementation of piperine in this study significantly ($P < 0.05$) affected eggshell weight. The result showed that eggshell weight in T0 (control) was significantly ($P < 0.05$) higher than the other treatments. The average of eggshell thickness in T0 (control) was significantly ($P < 0.05$) thicker as compared to those supplemented with piperine at the dose of 60 mg/kg BW (T4). However, there was no significant difference in eggshell thickness among treatments of T1, T2, and T3. This result was due to the addition of piperine into the feed could inhibit calcium transport into the mitochondria; the mitochondria will release calcium and stimulate the ATP-ase activity (SPI) (Duke *et al.*, 2012). Furthermore Yoon *et al.* (2015) stated that piperine would inhibit the enzyme activity of Ca²-ATP-ase in the transport of the calcium ions across the cell membrane that had an impact on decreasing calcium absorption. Inhibition of the calcium absorption resulted in the declining of egg quality such as egg weight and eggshell strength. According to Kebreab *et al.* (2009), the content of calcium and phosphorus in the diet can affect the weight and thickness of the eggshell. Eggshell quality and egg shape could be influenced by age and the content of mineral in the feed, such as calcium, magnesium, and phosphorus as inorganic constituent (Hincke *et al.*, 2011; Darmawan *et al.*, 2013). The mineral nutrients that contribute to the eggshell thickness and strength were calcium, magnesium, carbonates, phosphorus, vitamin D3, and other organic nutrients including protein (Leeson & Summers, 2005; Karoui *et al.*, 2009).

Haugh unit value is a measure of the quality of the eggs inside the shell. Haugh unit value obtained from the relationship between height of egg white (albumen) and egg weight. Supplementation of piperine at the dose of 30 mg/kg BW significantly ($P < 0.05$) increased Haugh unit compared to T0 (control) and T4, but it was not significantly different as compared to T1 and T2. The average of haugh unit was 91.81-94.45 (Table 3). The addition of piperine could improve the bioavailability of the nutrients, such as amino acid, glucose,

Table 3. Egg quality of laying quail at 9-13 weeks of age

Variables	Treatments				
	T0	T1	T2	T3	T4
Egg weight (g)	8.86 ±0.17	9.01 ±0.17	8.75 ±0.25	9.17 ±0.11	9.05 ±0.27
Albumen weight (g)	5.25 ±0.15	5.24 ±0.14	5.29 ±0.24	5.51 ±0.12	5.19 ±0.18
Albumen weight (%)	56.13 ±0.72	54.91 ±1.27	55.74 ±1.31	56.74 ±0.75	56.47 ±1.47
Yolk weight (g)	2.91 ±0.19	3.21 ±0.18	3.10 ±0.24	3.13 ±0.12	3.01 ±0.27
Yolk weight (%)	30.79 ±0.79	32.47 ±1.39	32.67 ±1.27	32.12 ±0.89	32.39 ±1.87
Egg shell weight (g)	1.18 ±0.07 ^a	1.12 ±0.07 ^b	1.10 ±0.05 ^b	1.09 ±0.03 ^b	1.03 ±0.02 ^b
Egg shell weight (%)	12.79 ±0.61 ^a	11.62 ±0.49 ^b	11.49 ±0.19 ^b	11.26 ±0.25 ^b	11.13 ±0.47 ^b
Eggshell thickness (mm)	0.168±0.005 ^a	0.165±0.006 ^a	0.162±0.00 ^{ab}	0.160±0.005 ^{ab}	0.155±0.006 ^b
Haugh unit	91.81 ±0.92 ^c	93.41 ±1.13 ^{ab}	93.15 ±0.86 ^{abc}	94.45 ±0.71 ^a	92.11 ±0.84 ^{bc}
Yolk color score	7.53 ±0.16 ^d	8.18 ±0.19 ^c	8.37 ±0.04 ^c	8.70 ±0.26 ^b	8.98 ±0.11 ^a

Note: T0= Control diet (without piperine), T1= T0 + piperine 15 mg/kg BW, T2= T0 + piperine 30 mg/kg BW, T3= T0 + piperine 45 mg/kg BW, T4= T0 + piperine 60 mg/kg BW. Means in the same row with different superscripts differ significantly ($P < 0.05$).

and beta-carotene (Atal & Bedi, 2010; Ahmad *et al.*, 2012). According to Nugraha *et al.* (2013), the increased absorption of amino acids could sustain ovomucin and lecithin that finally enhanced the quality of eggs, and amino acids were used to raise the viscosity of egg albumen that eventually increased Haugh unit. Furthermore, Honkatukia *et al.* (2013) explained that ovomucin was able to control the quality of the protein albumen and assisted the process of egg albumen viscosity. The content of ovomucin in the egg albumen affected the value of haugh units; the higher egg albumen resulted in the higher haugh unit values (Nugraha *et al.*, 2013). In this research, results showed that the egg produced in this experiment were included in grade AA. According to United States Department of Agriculture (USDA, 2011), egg haugh unit values above 72 are categorized as egg with grade AA, 60-72 as a grade A, 31-60 as a grade B, and less than 31 as a grade C.

The average of yolk score in this study was 7.53-8.98 (Table 3). Supplementation of piperine at a dose of 60 mg/kg BW significantly ($P < 0.05$) increased yolk score compared to the other treatments. Piperine supplementation at the doses of 15 and 30 mg/kg BW significantly ($P < 0.05$) increased yolk score as compared to T0 (control). The addition of piperine into the feed was able to increase the absorption of beta-carotene contained in the feed. According to Ahmad *et al.* (2012), piperine was able to increase the absorption of beta-carotene (a carotenoid) and other nutrients within the body. Carotenoid (beta-carotene) supported the high yolk color score since it had the same function with xanthophylls (Hermana *et al.*, 2014). Furthermore, Hammershoj *et al.* (2010) stated that egg yolk color was influenced by the consumption of zeaxanthin, lutein, alpha-carotene, beta-carotene, and carotenoids.

CONCLUSION

The addition of piperine at 15-45 mg/kg body weight could be used as phytochemical feed additive to improve performance, income over feed cost (IOFC), haugh unit and a yolk color.

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