Effect of fat supplementation containing high palmitic acid enriched with lecithin on quail performances

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Abstract. The aim of this study was to observe the effect of fat supplementation containing high palmitic acid enriched with lecithin on the performances of quail starter-grower phase. This study used a completely randomized design with 330 female day old quails Coturnix Coturnix Japonica randomized and entered into 5 treatments consisted of commercial feed (T0), T0 + 2.5% fat local + 6% lecithin from added fat (T1), T0 + 2.5% fat commercial + 6% lecithin from added fat (T2), T0 + 5% fat local + 6% lecithin from added fat (T3), T0 + 5% fat commercial + 6% lecithin from added fat (T4). The results showed that fat supplementation containing high palmitic acid enriched with lecithin was not significantly different (P<0.05) on body weight, daily body weight gain at the age of 36-42 days, feed consumption, feed conversion ratio, and mortality but daily body weight gain was significantly different (P<0.05) at the age of 8-35 days. Local fat supplementation containing high palmitic acid produced a higher income over feed cost than the control treatment and fat commercial treatment. Fat supplementation containing high palmitic acid enriched with lecithin did not interfere with quail health status as a whole.

1. Introduction

The demand for livestock products as a source of protein for the human is increasing because people are increasingly aware of the importance of nutritional needs. One of the animal products that is popular in the society is quail products. The advantages of quail have been cheaper production costs, resistance to disease making it a superior laboratory animal, fast growth, rapid generation intervals, fast adult sex, and the smallest animals for high egg productivity [1]. Quail eggs with a small size have been 3-4 times more nutrient content than the nutrient content of chicken eggs. The high of amino acids, fatty acids, vitamin E, iron and zinc in quail eggs has been good sources of nutrients for human health [2]. The advantages of quail are very appropriate to be developed and used as a producer of eggs in order to meet the needs of eggs for human.

The needed of the human for quail eggs is done by increasing the quality of feed which is the largest production cost of quail farms. The feed is needed as a support for quail performances. One way to improve feed quality and reduce feed deficiency is supplementing feeds from abundant natural resources and not widely used. One of the potential natural resources is the byproduct of the agricultural industry.

The palm oil industry is a natural resource that has potential and not widely used in the livestock industry. The process of making palm oil produces byproducts in the form of fat containing high palmitic acid. This fat can increase metabolic energy and increase the use of other nutrients such as proteins and fat-soluble vitamins. Fat can also help reducing heat increments and increasing
palatability when compared to high carbohydrate feeds [3]. Fats have insoluble properties in water so emulsifiers are needed to absorb fat in the body [4]. One emulsifier that can be used is lecithin. Supplementation of fat containing high palmitic acid enriched with lecithin is expected to improve quail performances. The purpose of the present study was to inspect the effect of fat supplementation containing high palmitic acid enriched with lecithin on the quail performances.

2. Materials and Methods

2.1. Time and Place
The study was conducted in December 2018 until May 2019, located at Kayumanis Quail Farm on Rawa Taman street number 180, Mekarwangi village, Tanahsereal Kodya district, Bogor. Proximate analysis of feed was carried out at the central laboratory of Bogor Agricultural University. Analysis of fatty acid profiles was carried out at the chemical integrated laboratory of Bogor Agricultural University.

2.2. Livestock
This study used 330 female day old quails (DOQ) Cortunix Cortunix Japonica and maintained until 42 days old. The initial body weight was weighed first at the beginning of maintenance. The animals were allocated into 5 treatments and 3 replications randomly with 22 quails each replication.

2.3. Lecithin
Lecithin used in this study was soy lecithin. Soy lecithin was a byproduct of industrial biodiesel from soybean oil. Soy lecithin was obtained from Saraswati Indo Genetech Ltd. Commercial fat containing high palmitic acid mixed with lecithin as much as 6% meanwhile in local fat containing high palmitic acid, lecithin mixed in the commercial feed as much as 6%.

2.4. Fat containing high palmitic acid
Fat containing high palmitic acid was a byproduct of palm oil. Local fat containing high palmitic acid was obtained from Asianagro Agungjaya Ltd and was an authentic Indonesian natural resource. Commercial fat containing palmitic acid was obtained from another country. Fat commercially containing high palmitic acid mixed with 6% lecithin from fat supplemented meanwhile lecithin in local fat containing high palmitic acid mixed in commercial feed with the same amount as commercial fat containing high palmitic acid.

Table 1. Fatty acid composition of fat supplemented.

| Fatty Acid            | C12:0 | C14:0 | C15:0 | C16:0 | C16:1 | C17:0 | C18:0 | C18:1n9t | C18:1n9c | C18:2n6c | C20:0 | C18:3n3 | C24:0 |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|----------|----------|----------|-------|---------|-------|
| Lauric acid           | 0.07  | 0.98  | 0.05  | 58.73 | 0.06  | 0.07  | 5.06  | 0.04     | 23.64    | 4.84     | 0.27  | 0.12    | 0.04  |
| Myristic acid         | 0.11  | 1.11  | 0.06  | 61.73 | 0.06  | 0.09  | 4.46  | 0.03     | 16.41    | 5.47     | 0.28  | 0.38    | 0.04  |
| Pentadecanoic acid    |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Palmitic acid         |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Palmitoleic acid      |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Heptadecanoic acid    |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Stearic acid          |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Elaidic acid          |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Oleic acid            |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Linoleic acid         |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Arachidic acid        |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Linolenic acid        |       |       |       |       |       |       |       |          |          |         |       |         |       |
| Lignoseric acid       |       |       |       |       |       |       |       |          |          |         |       |         |       |
2.5. Feeds
The feeds used commercial feed from Sinta Feedmill Ltd. The feed was given in the form of mash. The feed ingredients used in BR2 and SP2 were corn, bran, corn gluten, pollard, meat and bone flour, soybean meal, oil, calcium phosphate, calcium carbonate, sodium chloride, amino acids, vitamins, trace minerals, and antioxidants. The feed used for 1 to 35 days old was BR2 feed. Age 36 days to complete, quail was given SP2 feed. The nutrient content of the feed can be seen in Table 2.

| Nutrients             | BR2  | SP2  |
|-----------------------|------|------|
| Water content (%)     | 10.23| 9.20 |
| Ash (%)               | 4.69 | 13.94|
| Crude fat (%)         | 6.32 | 5.83 |
| Crude protein (%)     | 17.41| 17.37|
| Crude fiber (%)       | 1.96 | 2.33 |
| Gross Energy (kal/gram)| 4270 | 3886 |

2.6. Cages, Tools, and Materials
This study used 15 flocks of the cage and the sizes were 20 cm x 30 cm x 20 cm for the starter-grower phase (8-35 days) and 50 cm x 60 cm x 40 cm for layers phase (36-42 days). The equipment used in this study were cages, newspapers, cardboard boxes, 25-watt incandescent lamps, plastic, food and drink containers, scales, thermometers, calculators, and stationary. This material used in this study were 330 female DOQ, soy lecithin, local fat containing high palmitic acid, commercial fat containing high palmitic acid, and quail feed.

2.7. Procedures
2.7.1. Sample Testing. Analysis of fatty acid profiles of fat samples was measured by using AOAC (2012) method in the chemical integrated laboratory of Bogor Agricultural University using gas chromatography. The proximate analysis of feed was measured by using AOAC (2005) method in the central laboratory of Bogor Agricultural University.

2.7.2. Cage Preparation and Maintenance. The cage was prepared before DOQ arrived. The inside and outside of the cage, a place for feed, drinking water, and lights as heating, were cleaned and prepared. The study was conducted for 42 days. Activities carried out during maintenance were cleaning cages, cleaning drinking water places, and cleaning the environment around the cage.

Giving incandescent lights with 25 watts of power for each flock was used as lighting and heating for livestock. 25-watt incandescent lamp was used until 28 days in each flock and was used as lighting and heating. The age of 29 days until completion only used one 25 watt incandescent lamp as lighting.

Quail was given feed treatment for the adaptation process since the age of 1 day. Feed adaptation was carried out for 7 days with a ratio of 25:75% on days 1 and 2, 50:50% on days 3 and 4, 75:25% on days 5 and 6, and 100% on day 7. In health management, quails were given regular vaccinations to prevent an illness from coming. The first vaccine given to quails at 6 days was the ND IB vaccine and the second vaccine given to quails at 28 days was the ND AI Kill vaccine.

Quail was given feed and drinking water as ad libitum. Quail 1 to 24 days old were given drinking water using 1-liter gallon container. The manual gallon was replaced and washed every morning and afternoon. 25 days old quail to completion was given drinking water using 3-liter gallon container.
2.7.3. **Temperature Measurement.** The measurement of the temperature of the cage was carried out in the morning (6:00 a.m to 7:00 a.m), during the day (12:00 p.m to 1:00 p.m), and in the afternoon (04:00 p.m to 05:00 p.m). The daily temperature value was obtained by calculating the average temperature in the morning, noon, and afternoon. The night temperature was considered same as in the morning temperature.

2.7.4. **Experimental Design and Data Analysis.** The experimental design in this study used a completely randomized design because the quails had relatively uniform initial body weights, same cage, and same equipment. The data were analyzed by analysis of variance and continued with Duncan test to see differences between treatments (Steel and Torie 1993). Statistical analysis used SAS University 2019. The treatments were:

- T0 = Commercial feed (CE)
- T1 = Commercial feed (CE) + 2.5% local fat containing high palmitic acid (LF) + 6% lecithin from added fat (L)
- T2 = Commercial feed (CE) + 2.5% commercial fat containing high palmitic acid (CF)
- T3 = Commercial feed (CE) + 5% local fat containing high palmitic acid (LF) + 6% lecithin from added fat (L)
- T4 = Commercial feed (CE) + 5% commercial fat containing high palmitic acid (CF)

2.8. **Measured Variables**

2.8.1. **Body Weight (g).** Body weight was measured by weighing quails in each flock and divided by the number of quails in the flock.

2.8.2. **Daily weight gain (g day⁻¹).** Body weight gain was measured by weighing body weight per week and reduced body weight at the last week.

2.8.3. **Feed consumption (g day⁻¹).** Feed consumption was calculated from the average amount of daily feed and divided by the number of quails that live.

2.8.4. **Feed conversion ratio (g/g).** The feed conversion ratio was calculated from the average amount of feed consumption and divided by the body weight produced.

2.8.5. **Mortality (%).** Mortality (death) was obtained from the number of quails that die during the maintenance process and divided by the number of quails that survive.

2.8.6. **Income Over Feed Cost (IOFC).** IOFC was calculated by knowing the body weight produced on the amount of feed consumption and the price of quail. IOFC was obtained from a reduction in the total price of quail with the total cost of feed during the maintenance.
3. Results and Discussion

3.1. General Conditions of Cage Environment

Table 3. Environmental Temperature.

| Week- | (06.00-07.00 a.m) X ± SD | (12.00 a.m-01.00 p.m) X ± SD | (04.00-05.00 p.m) X ± SD |
|-------|-------------------------|-----------------------------|-------------------------|
| 1     | 30.75±0.50              | 33.75±1.50                  | 34.50±1.00              |
| 2     | 29.86±1.21              | 31.71±1.70                  | 32.43±2.30              |
| 3     | 30.29±0.95              | 33.86±0.90                  | 33.14±0.69              |
| 4     | 28.86±1.57              | 32.00±1.53                  | 30.43±1.40              |
| 5     | 27.14±1.07              | 29.86±1.21                  | 29.14±0.90              |
| 6     | 26.83±0.75              | 28.43±1.27                  | 28.57±1.51              |
| Average | 28.87±1.80           | 31.44±2.34                  | 31.13±2.46              |

The intensive farm requires good management. One factor that needs to be considered in the intensive farm is temperature. The temperature will affect the level of feed consumption and consumption of drinking water. Randall and Bolla [5] reported that the ideal temperature for the first week DOQ was 35°C and decreased 3.5°C per week. The different temperatures at week 1 to week 6 was due to different weather conditions each week. In table 3 shows that quails are in the normal temperature which ranges from 28-35°C.

3.2. Quail Performances

Table 4. Performances of quail 8-42 days old.

| Variables                  | T0          | T1          | T2          | T3          | T4          |
|----------------------------|-------------|-------------|-------------|-------------|-------------|
| Body weight g (8 days)     | 21.12±0.82  | 22.13±1.54  | 23.02±0.62  | 21.70±1.13  | 23.37±1.16  |
| Body weight g (35 days)    | 122.95±8.79 | 121.30±3.92 | 124.08±3.63 | 111.54±1.62 | 114.55±5.05 |
| Body weight g (42 days)    | 151.98±8.83 | 145.14±5.23 | 147.28±4.33 | 139.83±5.60 | 143.67±8.12 |
| Daily weight gain g day⁻¹ (8-35 days) | 3.64±0.29a | 3.54±0.09ab | 3.61±0.15a  | 3.21±0.09b  | 3.26±0.15b  |
| Daily weight gain g day⁻¹ (36-42 days) | 4.15±0.43  | 3.41±0.25   | 3.31±0.62   | 4.04±1.01   | 4.16±0.71   |
| Daily weight gain g day⁻¹ (8-42 days) | 3.74±0.24  | 3.51±0.11   | 3.55±0.12   | 3.38±0.13   | 3.44±0.20   |
| Feed consumption g day⁻¹ (8-35 days) | 12.20±0.41 | 12.01±0.61  | 12.01±0.52  | 11.37±0.26  | 11.48±0.47  |
| Feed consumption g day⁻¹ (36-42 days) | 19.29±0.86 | 18.10±0.31  | 19.32±0.85  | 17.72±0.75  | 18.27±1.33  |
| Feed consumption g day⁻¹ (8-42 days) | 12.84±0.40 | 12.36±0.57  | 12.64±0.44  | 11.80±0.41  | 12.03±0.53  |
| Feed conversion ratio g/g (8-35 days) | 3.36±0.17  | 3.39±0.13   | 3.33±0.22   | 3.55±0.18   | 3.53±0.13   |
| Feed conversion ratio g/g (36-42 days) | 4.69±0.65  | 5.08±0.53   | 5.97±1.17   | 4.58±1.19   | 4.45±0.58   |
| Feed conversion ratio g/g (8-42 days) | 3.44±0.21  | 3.52±0.06   | 3.56±0.03   | 3.50±0.05   | 3.50±0.06   |
| Mortality % (8-42 days)     | 0.20±0.17   | 0.20±0.17   | 0.30±0.00   | 0.40±0.46   | 0.30±0.00   |

*Treatments: T0:Commercial feed (CE), T1: CE+LF2.5%(L6%), T2: CE+CF2.5%(L6%), T3: CE+LF5%(L6%), T4: CE+CF5%(L6%)*
Fat supplementation containing high palmitic acid enriched with lecithin was not significantly different (P<0.05) on body weight, body weight gain at age 36-42 days, feed consumption and feed conversion but it was significantly different (P<0.05) on daily body weight gain at age 8-35 days. Fat supplementation did not damage overall quail performances, this is also in accordance with the recent studies [6,7] reported that supplementation fat for poultry feed formulated did not damage overall quail health status. The fat containing high palmitic acid which used is a byproduct of crude palm oil production. The fat was chosen because of its low price and high saturated fatty acid, and then it can reduce oxidation and peroxidation in adipose tissue rather than fat containing high polyunsaturated fatty acid [8]. Lecithin used in this study was 6% from added fat. According to Heugten and Odle [9] and Roy et al. [6] reported that lecithin levels more than 1% of added fat can improve fat digestion efficiency so that it can be used as an energy source and increased body weight. 6% of lecithin levels from the fat added in this study are not enough to help absorb fat perfectly. Fat absorption depends on factors such as carbon chain length, number of bonds, the presence or absence of ester bonds (triglycerides or free fatty acids), special regulation of saturated and unsaturated fatty acids on glycerol, free fatty acid composition, feed composition, type and the amount of triglycerides added in feed, intestinal flora, gender and age [10-12].

Body weights up to 42 days were not significantly different (P<0.05) but the average quail body weight at 42 days met the standard body weights for quail which will enter the layer phase. This result is in agreement with Filho et al. [13] reported that quail which have a body weight below 140 g will have lower egg weight and lower egg mass in the layer phase. The results of this study are also in agreement with several studies [6,14-16] which reported that supplementation of fat and emulsifiers was not significantly affecting body weight in the starter phase. This may be caused by the digestive system in the quail starter-grower phase is not perfect so that the absorption of fat supplemented is not perfect. That is also in agreement with several studies [3,14,17-27] reported that insufficient secretion of bile salts and the absence of lipase enzyme activity in the starter phase resulted in incomplete absorption of fat. Bile salts also stimulate the production of pancreatic lipase enzymes, which are affected mainly by the hormone Cholecystokinin (CCK) which is located in the intestinal mucosal crypt which is sensitive to the presence of fat.

Daily weight gain was significantly different (P<0.05) at 8-35 days but not significantly different (P<0.05) at 36-42 days. The daily weight gain in treatment T1 and T2 were not significantly different (P<0.05) with the control treatment (T0) but were significantly different (P<0.05) with T3 and T4 treatments. 6% of lecithin levels can help digestion of fat so that it can be used as an energy source for the quail starter-grower phase but the 6% of lecithin levels from the fat added are not enough to help digestion of fat perfectly in the quail starter-grower phase. This is in agreement with Lammasak et al. [3] which reported that there was a limit on the capacity of lecithin to form micelles with fatty acids and glycerol.

Feed consumption was not significantly different (P<0.05) because the quail starter-grower phase has an imperfective digestive organ so it is not perfect for digesting the fat supplemented, this is in agreement with recent studies [28-30] which reported that fat has a limited digestibility in young quails because the physiological functions needed for efficient fat digestion in young quails are immature and continue to develop for several weeks after hatching. The results of this study are in agreement with recent studies [31-33] which reported that an increase in fat content did not affect feed consumption.

The feed conversion ratio was used to determine feed efficiency consumed by quails. The feed conversion ratio was not significantly different (P<0.05). The results of the study were in agreement with recent studies [25-26,34] which reported that feed conversion which was not significantly different from increasing fat levels in the starter phase may be caused by the absence of lipase activity in the starter phase which causes lower fat absorption so that energy absorption was low. Quail feed conversion at the age of 42 days has met the standard of feed conversion in agreement with Widyatmoko et al. [35] which reported that the average feed conversion in quail was 3.77 with a range of 3.47-4.07.
Table 5. Income Over Feed Cost 8-42 days old.

| Variables          | T0            | T1            | T2            | T3            | T4            |
|--------------------|---------------|---------------|---------------|---------------|---------------|
| Feed consumption (kg) | 0.45          | 0.43          | 0.44          | 0.41          | 0.42          |
| Feed price (Rp kg)  | 6676.43       | 6681.25       | 6802.85       | 7172.5        |               |
| Feed price total (Rp) | 2888.07      | 3034.91       | 2809.78       | 3019.82       |               |
| Quail price (Rp)    | 12000         | 12000         | 12000         | 12000         | 12000         |
| IOFC               | 9056.83       | 9111.93       | 8965.09       | 9190.22       | 8980.18       |

*Treatments: T0: Commercial feed (CE), T1: CE+LF2.5%(L6%), T2: CE+CF2.5%(L6%), T3: CE+LF5%(L6%), T4: CE+CF5%(L6%)

The grower quail phase can also be sold to farmers as quails who are ready to lay. The highest IOFC available in T1 and T3 treatment because this is related to T1 and T3 treatments having a lower feed consumption than other treatment. The treatment of T3 and T1 has the advantage of a greater economic aspect than the other treatments as a whole in term of body weight was not significantly different (P<0.05) from other treatments.

4. Conclusion

Fat supplementation containing high palmitic acid enriched with lecithin did not interfere quail health status as a whole in term of mortality quails was not significantly different (p<0.05) with control treatment (T0). Local fat was not significantly affected (P<0.05) to body weight, daily weight gain, feed consumption and feed conversion ratio but the IOFC value was higher than the control treatment and fat commercial treatment. 6% of lecithin levels from the added fat in this study were not enough to help absorb fat perfectly. Further studies are therefore necessary to determine the effects of fat supplementation enriched with lecithin more than 6% from the added fat.

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