Research Article

Effects of Dietary Different Lipid Sources on Serum Cholesterol Concentration, Fat Composition and Growth Performance in Ducks

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Abstract | This research aims to determine the effects of various dietary fats on blood cholesterol, fat composition and the growth of male Bali ducks (*Anas sp*). The experiment used a completely randomized design (CRD) with four treatments and ten replicates of five duck per pen. The experimental diets were supplemented by using 0% oil (T0), 3% palm oil (T1), 3% palm oil that is used repeatedly (T2), 3% pork oil (T3) and 3% fish oil (T4), respectively. At the end of the treatment, body weight, feed consumption and feed conversion were recorded. Total cholesterol and fat composition were determined. The results showed that supplementation of different sources of fat significantly affected the total cholesterol, fat composition, and growth performance. Ducks received control feed (without oil) and feed with fish oil supplementation produced lower blood cholesterol and lower fat composition than palm oil and pork oil supplementation. The supplementation of fish oil and pork oil caused significantly increased growth performance. However, fish oil and pork oil supplementation produce higher cholesterol in blood serum than those other treatments. It is concluded that dietary different lipid source altered the blood lipid profile, and growth performance in duck

Keywords | Animal oil, Growth, Health, Vegetable oil

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INTRODUCTION

In recent decades, duck farming in Indonesia is very popular. The demand for duck meat and eggs has slightly increased. Even though duck farming has been carried out from generation to generation, however, as an industry, duck meat production in Indonesia is growing. Ducks can be considered potential sources of dietary protein for humans in Indonesia (Wandira et al., 2016). The duck's meat contains higher protein and cholesterol than chicken meat. Ducks are aquatic avians with a high lipogenesis rate to fulfill their energetic requirements during a long migratory flight (Guglielmo, 2010). A previous study shows that the percentage of body fat could be reached 1,84% in Indonesia's local ducks (Suryanti et al., 2014). Although duck meats are popular with their unique flavor and juicy texture, the health concern was rose because of the high content of fat.

Nowadays, a new concept of health has been introduced by bioscience. Fat does not have a good image for human health, although fat is an important energy resource. Consumption of animal foods with high fat is avoided because it is a cholesterol source (Meliandasari et al., 2015). Currently, diseases such as cardiovascular disease, cancer, and obesity are caused by food consumption with high fat and cholesterol (Micha et al., 2010; Pan et al., 2012). Every 300 mg of cholesterol consumed per day significantly higher risk ration of cardiovascular disease incident (Zhong et al., 2019). Therefore, the demand for healthier products was rising and has influenced the development of fatless and lower cholesterol meat products.

The controlling of the diet can partly control the cholesterol and fat content in duck meat. Supplementation of different oil content sources in the animal feed was used to reduce fat or cholesterol level in duck meat (Schivone et al., 2010). In the current poultry industry, the common use of oil in feed formulation (Edi et al., 2018). Currently, animal fat is commonly added as a source of oil to animal feed. Animal fat is generally highly saturated, which means that the animal fat solidifies at a relatively high temperature. A previous study indicated that oil from pork supplementing into pig feed could increase feed efficiency and increase body weight. Oil pork typically contains 40% saturated fatty acid (Oroian and Petrescu-Mag, 2015) and contains 9004.49 kcal/kg of metabolized energy (Razali et al., 2018).

Fish oil is the third most used dietary supplement, after vitamins and minerals now. Diet added fish oil that contains fatty acids would protect the hearts. Ingestion of fish oil or fish is the most direct method of increasing tissue concentrations of the n–3 long-chain PUFAs (LCPUFAs)[3] EPA and DHA (Gregory and James, 2014).

Vegetable oils are non-cholesterol and have a higher ratio of unsaturated to saturated fatty acids than animal fats. The use of feed contains polyunsaturated fatty acid (PUFAs) in including plant oils, is beneficial for consumers' health since these acids improve the dietetic value of meat. They significantly increase the proportions of n-3 fatty acids like linolenic acid but do not influence the proportion of DHA and EPA (Jasinska and Kurek., 2017).

The oil palm tree is an ancient tropical plant that originated from West Africa and has a long history of use as medicine and food. The oil is the source of β-carotene, palmitic acid, and vitamin E. It contains triacylglycerol and fatty acid (FA), the only oil balance composition of unsaturated and saturated fatty acids (Mba et al., 2015). The previous publication indicated that palm oil could improve body weight gain and feed efficiency in goats (Adhianto et al., 2020).

Omega-3 polyunsaturated fatty acids (n-3 PUFA) play a vital function in human health since they help reduce the incidence of lifestyle diseases such as coronary artery diseases (Simopoulos, 2000). Study on Japanese quail, the levels n-3 PUFA content in meat could be increased by added oil in diet formulation (Ebeid et al., 2011). A previous study showed that n-3 polyunsaturated fatty acids (n-3 PUFA profile in meat could be altered by adding fish products to the feed for broilers (Cortinas et al., 2004). The modification of the fat composition in favor of higher o-3 PUFAs in replacing o-6 PUFAs and saturated fatty acids (SFAs) may provide promising healthy benefits (Chen et al., 2017).

This study aims to assess the change of fatty acid profiles in the blood serum duck, the fat composition and growth performance after feeding supplement various dietary fats, including palm oil, pork oil, and fish oil.

MATERIAL AND METHODS

A total of two hundred ducks were used in this experiment, with mean body weight was 204 ± 21.24g were randomly assigned into five dietary treatment groups including a control group (each group with 10 replicates of 5 ducks). Treatments in this experiment consisted of 5 groups: feed ducks without using oil (T0), feed ducks using 3% palm oil (T1), feed ducks using 3% palm oil for repeated use (T2), feed ducks using 3% pork oil (T3), and feed the ducks using 3% fish oil (T4). Ducks were fed a diet made from feed ingredients: yellow corn, concentrate, rice bran, NaCl, mineral mix, and oil. Pork oil is obtained by heating lard above its boiling point of 1000C (Razali et al., 2018). The feed was prepared with the same energy content (2900 kcal/kg) and protein (16%), according to the NRC standard (1994). Diets and water were given ad libitum. The composition of feed ingredients and nutrient content are presented in Table 1. At the end of the 56 days dietary treatment, ducks were sacrificed and blood and fat were collected for further evaluation.

Measurements

Growth performance: The ducks were weighed and feed intake was recorded on day 14. and end of the treatment (day 70). Bodyweight gain (BWG), feed intake and feed conversion were calculated. The feed consumption is calculated every day by reducing the feed and feed side the next day. Weight gain was calculated by reducing the final body weight (ducks aged ten weeks) with initial body weight (ducks aged two weeks). Feed conversion was calculated by dividing the ducks' feed consumption per day by the ducks' weight gain per day.

Carcass traits: At the end of the experiment, all ducks were slaughtered for the evaluation of fat composition (visceral fat, mesenteric fat, pad fat, carcass fat),

Blood analysis: blood sample was collected from the jugular vein by expending the sterilized needles besides randomly certain syringes and placed on anticoagulant tubes with EDTA to collect serum. Serum cholesterol, LDL, triglycerides, and HDL estimation were carried out using the Boehringer method (1996).

Data analysis

All data were analyzed using a one-way analysis of variance. Significant differences between treatment means

Table 1: Chemical analysis of diets used in the experiment.

Ingredients	Compositions (%)				
	T0	T1	T2	T3	T4
Yellow corn	50	24	24	25.5	26
Concentrate144	38	34	31.5	30	29.5
Rice bran	11.3	38.3	41.5	41.5	41.5
NaCl	0.2	0.2	0.2	0.2	0
Mineral Mix	0.5	0.5	0.5	0.5	0
Palm oil	0	3.0	0	0	0
Palm Oil is used repeatedly	0	0	3.0	0	0
Pork oil	0	0	0	3.0	0
Fish oil	0	0	0	0	3.0
Total	100	100	100	100	100
Chemical composition *)					
Metabolizable energy (Kcal/kg)	2921.60	2933.60	2906.95	2909.95	2939.95
Crude Protein (%)	16.08	16.54	16.39	16.17	16.18
Calcium (%)	0.78	0.73	0.68	0.65	0.65
Phosphor (%)	0.46	0.45	0.43	0.41	0.41
Lipid (%)	4.19	6.62	6.89	6.93	6.94
Crude Fiber (%)	3.01	5.57	5.93	5.94	5.94

*) Proximate analysis
T0: ducks received diets without any supplements.
T1: ducks supplemented with 3% palm oil without repetition
T2: ducks supplemented with 3% palm oil with repetition.
T3: ducks supplemented with 3% pork oil.
T4: ducks recieved 3% fish oil.

were separated by Duncan's multiple range test (Steel and Torrie, 1980). All results were statistically analyzed using the SPSS Version.22.0 software. A value of $P < 0.05$ was considered to be statistically significant.

RESULT AND DISCUSSION

Cholesterol profile in duck blood serum

Treatment with fish oil supplementation in duck feed can reduce total cholesterol in blood serum. Fish oil most effective for lowering total cholesterol levels in this study. Duck giving 3% fish oil was not significantly different from the giving without oil (T0). Results of analysis of blood cholesterol profile are presented in Table 4. In serum, concentrations of LDL-cholesterol and triglyceride were significantly lower in duck fed diets supplemented with fish oil (T4) than those of the control group ($p<0.05$). Palm oil supplementation decreased the serum concentrations of HDL-cholesterol, but the difference was not as significant as those of the control group ($p>0.05$).

Recently, n-3 PUFA as a dietary supplement has decreased fat and cholesterol contents in meat. Fish oil is a common source of PUFA and plays an essential role in health since it helps reduce the incidence of lifestyle diseases such as coronary artery diseases. PUFA can modify the composition of fatty acid (FA) of meat (Ebeid et al., 2011). Fish oil in this study able to decrease the cholesterol content of duck serum. According to Arini et al. (2017), fish oil contains omega-3 fatty acids that lower cholesterol levels. Fish oil could balance blood lipid profiles by lowering plasma triglycerides, LDL, cholesterol and raising plasma HDL. Production of such meats with low cholesterol, LDL cholesterol and triglyceride is feasible and could be realized by adding fish oil in duck diet formulation.

Palm oil, especially as part of an overall low-fat diet, has effectively maintained lipoprotein cholesterol and total cholesterol values. Some studies have found that palm oil may help decrease bad LDL cholesterol (Nyquist et al., 2013). The addition of palm oil to animal feeds leads to changes in the fatty acid (FA) of rabbit and chicken meat, liver and plasma. The effect of palm oil on fatty acid corresponds to the fatty acid composition (Tres et al., 2012).

In this study, the pork oil supplementation in duck feed caused increased cholesterol content. Pork oil contains saturated fatty acid (SFA) and cholesterol (Razali et al., 2018). The SFA content of pork fat 39 g/100 g fat (Gupta and Khosla, 2000). It has been known that the fatty acid

Table 2: effects of various oil supplementation on lipid profile of male Bali ducks.

Variables	Group					SEM[1]
	T0	T1	T2	T3	T4	
Cholesterol concentration (mg/dl)	143.79[b2]	199.20[a]	186.42[a]	205.62[a]	140.45[b]	21.02
LDL (mg/dl)	48.06[b]	66.43[a]	68.18[a]	92.74[a]	43.24[b]	8.74
HDL (mg/dl)	98.18[a]	90.68[a]	104.82[a]	100.38[a]	110.68[a]	17.47
Triglycerides (mg/dl)	55.34[b]	79.55[a]	101.46[a]	94.22[a]	46.86[b]	2.16

[1]SEM: standard error of treatment means

[2]b: Means with different superscripts within rows are significantly different (P <0.05)

LDL: Low Density Lipoprotein

HDL: High Density Lipoprotein

Table 3: effects of various oil supplementation on growth performance of male Bali ducks

Variables	Group					SEM[1]
	T0	T1	T2	T3	T4	
Body weight at 2 weeks (g)	205.18[a]	204.57[a]	207,71[a]	201,94[a]	208.77[a]	8.04
Body Weight at 10 weeks (g)	1512.28[b2]	1525.26[b]	1507.56[b]	1585.52[a]	1575.12[a]	31,03
Weight gain (g / day)	163.39[b]	165.09[b]	162.48[b]	172.95[a]	170.79[a]	11,39
Feed consumption (g / bird / day)	542.45[a]	559.66[a]	554.06[a]	552.31[a]	587.52[a]	64,92
Energy Consumption (Kcal / bird / day)	1577.66[b]	1642.82[a]	1610.45[a]	1606.29[a]	1727.28[a]	42.58
Protein Consumption (g / bird / day)	87.23[b]	92.57[a]	90.81[a]	89.31[a]	95.06[a]	8,71
Feed conversion ratio (feed consumption:body-weight gain)	3,32[a]	3,39[a]	3,41[a]	3,02[b]	3,44[a]	0,24

[1]SEM: standard error of treatment means

[2]b: Means with different superscripts within the same row are significantly different (P <0.05)

Table 4: Effects of various oil supplementation on carcass traits on male Bali ducks. Composition

Variables	Group					SEM[1]
	T0	T1	T2	T3	T4	
Slaughter Weight (g)	1514.64[b2]	1528.98[b]	1510.66[b]	1576,24[a]	1580.62[a]	32,35
Carcass Weight (g)	893.64[b]	886.79[b]	876.15[b]	914.22[a]	916.52[a]	17,15
Percentage of Carcass (%)	58,62[a]	57,88[a]	57,78[a]	58,04[a]	58.22[a]	12.28
Visceral fat (g)	3.54[b]	4.24[a]	4.84[a]	4.96[a]	4.02[a]	0.97
Pad fat (g)	0.51[a]	0.56[a]	0.58[a]	0.55[a]	0.48[b]	0.04
Mesenteric fat (g)	0.27[b]	0.41[a]	0.46[a]	0.48[a]	0.31[b]	0.03
Abdominal Fat (g)	4.32[b]	5.21[a]	5.88[a]	5.99[a]	4.33[b]	0,89
Carcass Fat (g / 100g carcass)	23.54[a]	24.02[a]	24.12[a]	24.26[a]	23.67[a]	8.17
Meat Carcass	31.08[a]	31.66[a]	31.78[a]	32.08[a]	32.18[a]	9.04
Bone Carcass	45.38	44.32	44.10	43.66	44.15	11,88
Meat Bone Ratio	0.68[a]	0.71[a]	0.72[a]	0.73[a]	0.73[a]	0.05

[1]SEM: standard error of treatment means

[2]b: Means with different superscripts within rows are significantly different (P <0.05)

composition of feed affects the fatty acid composition of meat and other animal products (Dalle Zotte and Szendro, 2011). Thus, special attention should be given to selecting the source of fat added to the feeds.

Growth Performance

The supplementation of different fat sources in the feed significantly affected the growth performance of 14-70 day-old meat ducks (P < 0.05). This study showed that differences were observed in initial body weight (IBW) and final body weight (FBW). Bodyweight was the highest in duck given feed supplementation with pork oil compared with other treatments. Only duck feed with fish oil was the lowest body weight compared to the other treatment (Table 3). Ducks that fed the five different fat sources in diets had significantly (p<0.05) different weight gains (WG). Besides, weight gain was higher in duck fed pork oil supplementation than those fed other treatment. Weight gain was the lowest in duck fed fish oil supplementation.

Fat is usually used high-energy ingredient in poultry feed. Various animal fats and vegetable oils are usually added to increase energy density to improve poultry's growth performance (Zhao and Kim, 2017). Many studies have reported that the oil supplementation to poultry diets can increase the diet's energy concentration, improve poultry's performance, and improve production efficiency (Zampiga et al., 2016). A previous study showed that in Pekin duck, fed oil from different sources influences the growth performance (Ao and Kim, 2020). This study found that pork oil significantly affected 14- to 70-day-old meat ducks' growth performance. It was indicated, pork oil can be used in the feed to increase final body weight in duck, thereby reducing the feed cost and improving economic benefits
Feed consumption in this research was similar (P>0.05) among all the groups (Table 3). In this study, the diet of different lipid sources is not significant in feed consumption. This result due to the fat contained the same energy (2,900 Kcal/kg) and the same crude protein (16%) (Nuriyasa et al., 2020). Meanwhile, the lowest energy consumption was dietary without oil supplementation (Control). Alice et al. (2006) stated that the presence of oil in the feed could reduce the feed's dusty, make it more attractive, increase palatability and reduce nutrient loss. This condition causes higher feed consumption and, as a consequence is higher energy and protein consumption.

Duck feed containing pork oil (D) caused the lowest feed conversion ratio with 3.02 to compare to other treatments. Dietary does not affect the feed conversion ratio because higher body weight is generated due to higher feed consumption (Nuriyasa et al., 2016).

Ducks treated with fish oil (T4) produced the greatest slaughter weight, which was 1580.62 g, Pork oil (T3) was not significantly lower (P>0.05) than treatment fish oil (T4). While treatments control (T0), palm oil (T1), and supplementation of palm oil are used repeatedly as an energy source (T2) were significantly lower (P <0.05), respectively, than fish oil supplementation. The duck was fed with fish oil supplementation produced the greatest carcass weight (916.52 g). Meanwhile, palm oil supplementation (T2) was showed the lowest. The slaughter weight and carcass weight of ducks that received pork oil and fish oil supplementation were higher due to the higher final weight (10 weeks old ducks) in pork oil and fish oil supplementation. Oil supplementation improves the palatability of diets, reduces the dustiness of feeds, and decreases the passage rate of feed through poultry's intestinal tract, which gives more time for the adequate absorption of all nutrients present in the diet (Chwen et al. 2013). Higher feed consumption causes higher energy and protein consumption so that the growth of ducks is higher, as in Table 2. The results of this study are in accordance with the research by Puger and Nuriyasa (2017), which states that a higher final weight will result in higher slaughter weight and carcass weight. The ducks were fed dietary with palm oil supplementation produced percentage of the carcass was 57.78%, which was not significantly different (P> 0.05) compared to other treatments. The carcass percentage was not affected by all feed treatments because ducks produced a higher carcass weight with a higher slaughter weight (Nuriyasa et al., 2018).

The visceral fat in the ducks treated without oil supplementation (T0) was 3.54g, while the ducks given with other dietaries were significantly higher (P<0.05). The lowest pad fat was produced by ducks that received fish oil supplementation (0.48g), while the other treatments were significantly higher (P<0,05) than fish oil supplementation (T4). The lowest mesenteric fat occurred in ducks that were given with control feed (T0) (0.27g), while the highest was in the ducks that fed dietary with pork oil supplement (0.48g). The control feed (T0) produced the lowest abdominal fat (4.32g). in contrast, the highest was that given pork oil supplement (5.99g). In this research, ducks that given dietary with oil supplementation showed higher Visceral fat, pad fat, mesenteric fat, abdominal fat and total carcass fat than in ducks fed without oil supplementation. Dietary fats produce an extra calory effect, in which the net energy value for maintenance and production is greater than would be predicted by apparent metabolizable energy measurement (Tomkins and Drackley, 2010). Pie et al. (2004) states that oil in feed functions as a concentrated source of energy. This makes excessive consumption is stored in the form of body fat.

The diets with different fat sources significantly result in carcass weight (P<0.05) of ducks. The duck given with fish oil supplementation showed the highest meat component from the carcass (32.18g/100g) compare to other treatments. The lowest carcass bone (43.66g/100g) is shown by ducks that received dietary with pork oil (T3) supplement. The other treatments showed a higher result than fish oil (T4). Ducks that given pork oil (T3) supplement and fish oil (T4) produced the same meat bone ratio (0.73) while the others were lower than those. Oil increases the absorption of vitamins A, D, E and K, circulates essential fatty acids. Moreover, oil also increases the efficiency of feed use, increases the absorption of vitamin A and carotenes in the digestive tract, and is important in calcium absorption of feed (Shurson et al., 2015). Fat and meat components were higher in ducks treated using oil supplementation. As a result, the bone component was lower, and the meat bone ratio was quantitatively higher than the control feed, according to the opinion of Nuriyasa et al. (2018).

CONCLUSIONS

Duck feed with fish oil and pork oil supplementation produces better growth than those fed with palm oil supplementation. Pork oil supplementation produces higher fat and cholesterol content of the serum than those fed with palm oil and fish oil supplementation.

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AUTHORS' CONTRIBUTIONS

MN and AWP compiled the research idea, IGAAP performed the analysis of duck blood serum, IMN was responsible for statistical analysis, all authors contributed equally to the writing of the final manuscript.

CONFLICT OF INTEREST

The authors states that they have no conflict of interest.

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