Original Article

Comparative effect of DL-methionine and DL-methionine hydroxy analogue supplemented diet on productive performance, fat accumulation and lipid profile in blood of meat-type ducks

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Abstract

The objective of this study was to compare the effect of DL-methionine (DLM) and DL-methionine hydroxy analogue (DL-MHA) supplementation on the growth performance, carcass quality, fat accumulation and lipid profile in blood of meat-type duck. Three hundred male Cherry Valley ducks were divided into 3 groups with 4 replications of 25 ducklings each. Each group was given a diet as follows: 1) basal diet, 2) basal diet + DLM, and 3) basal diet + DL-MHA. The results show that dietary supplementation with DLM and DL-MHA increased body weight ($P<0.01$), feed intake ($P<0.01$) and pectoralis major ($P<0.05$), but decreased abdominal fat ($P<0.01$) when compared to the basal diet. Supplementation with DL-MHA also resulted in greater levels of triglycerides ($P<0.05$), low-density lipoprotein ($P<0.05$) and cholesterol ($P<0.05$) in the blood compared to the DLM group, in addition to greater levels of triglycerides ($P<0.05$) and high-density lipoprotein ($P<0.05$) compared to the basal diet. Furthermore, supplementation with DLM was shown to lower the level of plasma uric acid ($P<0.05$) compared to the basal diet. It is concluded that DL-MHA can promote the same productive performance in meat-type ducks as DLM, but the fat accumulation and lipid profile in blood was greater with the DL-MHA supplementation than with DLM. Furthermore, the underlying mechanism of different effects between DL-MHA and DLM on the lipid metabolism in ducks should be further investigated.

Keywords: DL-methionine, DL-methionine hydroxy analogue, fat accumulation, meat-type duck, productive performance

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Introduction

In poultry nutrition, methionine (Met) is considered as the first-limiting amino acid, particularly in a corn-soybean based diet (Jianlin et al., 2004). Due to the sparing effect of cystine, Met can be supplemented in diets to meet the total sulfur amino acid (SAA) requirement for poultry (Bunchasak, 2009). DL-methionine (DLM) and DL-methionine hydroxy analogue (DL-MHA) are forms of synthetic Met, which are widely used in livestock feed (Bunchasak, 2014). The supplementation of Met in the diet of white Peking ducks has an enormous impact on growth performance and carcass quality (Xie et al., 2006), while the Met requirement in modern white Peking ducks seems to be higher than that of the NRC (1994) recommendation (Xie et al., 2004). Furthermore, the biological efficacy of DL-MHA in meat-type ducks for weight gain was similar to that of DLM when it was included in the diet as the same Met equivalent (Kluge et al., 2016). With regard to commercial feed ingredients or maximal SAA requirement, it has been recently suggested that the bioefficacy of DL-MHA was 88% (wt/wt) of the value for DLM, on a product-to-product basis, for growth performance of broiler chickens (Bunchasak and Keawarun, 2006). However, the Met or SAA requirements in meat-type ducks are generally lower than those requirements in broiler chickens (Cherry Valley Farm, 2004; Ross 308, 2014; Grimuad Freres, 2010).

The function of methionine is closely related to lipid metabolism (Wong et al., 1977; Tillman and Pesti, 1986; Chen et al., 1993). In broiler chickens, liver triglycerides and fat accumulation are enhanced in response to SAA supplementation (Bunchasak and Silapasorn, 2005), as Met may disturb the ability of lipid transportation (Bunchasak et al., 1997). In terms of Met source, the effect of DLM on fat metabolism in broiler chickens is different from that of DL-MHA (Esteve-Garcia and Llauradó, 1997, Bunchasak and Keawarun, 2006) and efficiency in the anti-lipogenic role of Met has been reported to be lower in DL-MHA than in DLM (Esteve-Garcia and Llauradó, 1997). Higher subcutaneous fat accumulation in ducks has been shown to provide insulation and tolerance to low temperatures (Bochno et al., 2013), whereas their abdominal fat accumulation is lower than in broiler chickens (Sakulthai, 2013). The differences of some metabolic pathways involving fat metabolism between these species have been investigated (Mooney and Lane, 1981; Hermier, 1997; Jin et al., 2001). It is hypothesized that due to the unique nature of fat accumulation and physiological functions of ducks, the bioefficacy of DL-MHA compare to DLM may be different from other animal species. Therefore, the objective of this research was to study the effects of DLM in comparison to DL-MHA on the growth performance, carcass quality and lipid profile in blood of meat-type duck.

Materials and Methods

Animals and management: The research was performed at the Animal Research Station (Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok), and all animal care procedures were conducted according to the regulations of the Institute of Animal for Scientific Purposes Development. Three hundred male, meat-type ducks (Cherry Valley) were used in the experiment. The ducklings were divided into 3 groups with 4 replications of 25 ducklings each. Floor pens (0.2 m^2 per bird) were located in an evaporative cooling system. The temperature was set at 33°C at one-day-old and then was decreased by 1°C at 3-day intervals until a final temperature of 25°C was reached. The lighting and vaccination were managed according to the recommended requirements for the strain. Each pen was equipped with two hanging feeders and six nipple drinkers. Feed and water were provided *ad libitum* throughout the period of the study.

Experimental design and diets: A completely randomized design was used. Three experimental diets (pellet form) were provided as shown in Table 1 as follows: 1) basal diet, 2) supplementation with powder form of DLM (Sumitomo Chemical Co., Ltd, Tokyo, Japan) to meet the recommended requirements for Cherry Valley ducks (Cherry Valley Farms, 2004) at levels of 2.6, 2.6, 3.2 and 3.6 g/kg for 0 to 9, 10 to 16, 17 to 42 and 43 to 47 days of age, respectively, and 3) supplementation with a liquid form of DL-MHA (88% of bioefficacy of the DLM on a product-to-product basis, wt/wt; Sumitomo Chemical Co., Ltd, Tokyo, Japan) to meet the recommended requirements for Cherry Valley ducks (Cherry Valley Farms, 2004) at levels of 3.0, 3.0, 3.6 and 4.1 g/kg for 0 to 9, 10 to 16, 17 to 42 and 43 to 47 days of age, respectively.

Chemical analyses: Official standard methods (AOAC, 2000) were used to determine the contents of crude protein. The crude protein was calculated as N × 6.25. Concentrations of lysine, methionine, cystine and threonine in the basal diet were determined using ion-exchange chromatography with post-column derivatization with ninhydrin (Llames and Fontaine, 1994). Tryptophan was determined using HPLC with fluorescence detection (extinction 280 nm, emission 356 nm), after alkaline hydrolysis with barium hydroxide octahydrate for 20 h at 110°C according to the procedure outlined by Commission Directive (2000). Total sulfur amino acids were calculated using methionine plus cystine. The calculated metabolizable energy and analyzed chemical composition are shown in Table 1.

Growth performance and carcass quality: All ducks were weighed individually at the start and end of each phase. Feed intake was also recorded at the end of each phase. The average daily gain (ADG) and feed conversion ratio (FCR) were calculated on a per pen basis. The protein intake and SAA intake were calculated from the feed intake. At the end of the experiment (47 days of age), after overnight feed deprivation, all the ducks were weighed. One duck from each pen was sacrificed by asphyxiation using CO_2 in an atmosphere of less than 2% oxygen (air displaced by CO_2) for 1.5-2.0 mins. After the carcasses had been chilled at 4°C for 4 h, skin with subcutaneous fat covering the pectoralis major area was removed. The pectoralis major (outer breast meat), pectoralis

minor (inner breast meat), drumette, leg meat (including thigh and drum stick) and abdominal fat pad, including the fat surrounding the gizzard, were removed manually and weighed.

Table 1 Basal diet (g/kg, as fed-basis) and chemical composition in each period of growth.

Ingredient	Starter 1 (0 to 9 d)	Starter 2 (10 to 16 d)	Grower (17 to 42 d)	Finisher (43 to 47 d)
Corn (8.1% CP)	299.3	299.3	298.1	297.8
Corn starch	3.0	3.0	3.6	4.1
Broken rice (7.7% CP)	35.5	129.7	106.7	144.0
Rice bran (13.8% CP)	129.2	27.1	90.2	100.0
Defatted rice bran (14.4% CP)	-	-	9.8	-
Wheat bran (14.8% CP)	145.6	200.0	200.0	200.0
Oil	40.0	40.0	40.0	39.4
Soybean meal (47.2% CP)	304.4	256.7	213.3	176.5
Limestone	16.7	16.3	19.8	20.4
Mono-dicalcium phosphate (21.0% P)	15.8	17.3	9.2	8.1
Sodium chloride	4.2	4.2	4.2	4.2
Choline chloride (75.0%)	0.8	0.8	0.8	0.8
Antimold	0.5	0.5	0.5	0.5
Antioxidant	0.1	0.1	0.1	0.1
Vitamin and trace mineral premix[1]	1.5	1.5	1.5	1.5
DL-Methionine	-	-	-	-
L-Lysine-HCL	2.6	2.3	1.4	1.2
L-Threonine	0.8	1.2	0.8	1.4
Chemical composition (g/kg, as dry matter basis)				
Metabolizable energy[2] (kcal/kg)	2,850	2,900	2,900	2,950
Crude protein	220.0	200.0	185.0	169.9
Methionine	2.9	2.7	1.3	0.9
Total sulfur amino acids[3]	6.4	5.8	4.3	3.4
Lysine	13.5	11.7	10.0	8.8
Threonine	9.0	8.5	7.5	7.5
Tryptophan	2.6	2.4	2.2	2.0

[1]Vitaimin and mineral premix content (per kg of diet): retinyl acetate 4.13 mg, cholecalciferol 75 µg, α-tocopherol acetate 13.5 mg, vitamin K_3 1.5 mg, vitamin B_1 1.5 mg, vitamin B_2 5 mg, vitamin B_6 2 mg, vitamin B_{12} 0.05 mg, niacin 25 mg, Ca-D-panthothenate 8 mg, folic acid 3 mg, biotin 0.12 mg, choline chloride 0.16 mg, antioxidant 30 mg, manganese 80 mg, zinc 60 mg, iron 40 mg, copper 8 mg, iodine 0.05 mg, cobalt 0.10 mg, selenium 0.10 mg.
[2]Calculated metabolizable energy (g/kg, as dry matter basis)
[3]Methionine + Cystine

Sampling procedures and biochemical analyses: Blood samples were collected from the wing veins of 3 randomly selected ducks in each replication. The 5 ml samples were transferred into two plastic vials containing EDTA as an anticoagulant and free-EDTA, respectively. Whole blood samples with EDTA were centrifuged at 3,000×g for 10 mins at room temperature. Serum was obtained from the whole blood with free-EDTA for 10 mins at room temperature. The plasma and serum samples were stored at -20°C until chemical analysis. The plasma uric acid and triglyceride concentrations were analyzed using the PAP-method (Assay Kit, Human Gesellschaft für Biochemica und Diagnostica GmbH, Germany). Serum LDL, HDL and cholesterol were measured using commercially available enzyme colorimetric test kits (Roche Diagnostics GmbH, USA).

Statistical analysis: The homogeneity of variances and normal distribution of the data was confirmed using the UNIVARIATE procedure of SAS (SAS, 2009). All data in each dietary treatment was analyzed by ANOVA using GLM procedure of SAS (SAS, 2009). The significance of differences between the treatment group means for all traits was evaluated using Duncan's multiple range test, and the significant level was set at $P<0.01$ and $P<0.05$.

Results

The effects of Met sources on growth performance are presented in Table 2. From 0 to 9 days of age, ducks fed DLM and DL-MHA significantly increased ($P<0.01$) BW, ADG, feed intake, protein intake and SAA intake compared to the basal diet. From 10 to 16 days of age, ducks fed DL-MHA showed the highest ($P<0.01$) BW and ADG when compared to DLM and basal diet, whereas ducks fed DLM and DL-MHA improved ($P<0.01$) feed intake, protein intake and SAA intake compared to the basal diet. From 17 to

42 and 43 to 47 days of age, ducks fed DLM and DL-MHA significantly increased (P<0.01) BW and SAA intake. From 43 to 47 days of age, ducks fed DLM and DL-MHA significantly increased (P<0.01) BW and SAA intake. Over all periods (0 to 47 days of age), ducks fed Met (DLM or DL-MHA) significantly increased (P<0.01) final BW, ADG, feed intake, protein intake and SAA intake compared to the basal diet. However, there was no difference (P>0.05) in the FCR among the three groups.

Table 2 Effect of methionine supplemented diet on growth performance of ducks from 0 to 47 d of age.

Item	Experimental diets			SEM	P-value
	Basal	DLM	DL-MHA		
		0 to 9 day of age			
BW (g)	254.80^{B}	347.95^{A}	377.03^{A}	17.90	<0.01
ADG (g/day)	22.91^{B}	33.26^{A}	36.50^{A}	1.99	<0.01
Feed intake (g/day)	25.50^{B}	39.80^{A}	39.86^{A}	2.09	<0.01
FCR	1.11	1.20	1.11	0.03	0.42
Protein intake (g/day)	6.57^{B}	8.76^{A}	8.77^{A}	0.38	<0.01
SSA intake (mg/day)	16.37^{B}	35.82^{A}	35.87^{A}	2.79	<0.01
		10 to 16 days of age			
BW (g)	729.86^{C}	868.81^{B}	924.62^{A}	25.18	<0.01
ADG (g/day)	69.58^{B}	72.70^{B}	81.48^{A}	1.84	<0.01
Feed intake (g/day)	95.39^{B}	109.40^{A}	111.14^{A}	2.27	<0.01
FCR	1.37	1.52	1.38	0.03	0.12
Protein intake (g/day)	19.08^{B}	21.88^{A}	22.23^{A}	0.45	<0.01
SSA intake (mg/day)	31.20^{B}	91.89^{A}	93.36^{A}	8.74	<0.01
		17 to 42 days of age			
BW (g)	2941.70^{B}	3100.93^{A}	3149.17^{A}	31.40	<0.01
ADG (g/day)	85.14	86.52	85.79	0.68	0.75
Feed intake (g/day)	193.58	197.91	197.53	1.03	0.16
FCR	2.29	2.32	2.41	0.03	0.26
Protein intake (g/day)	35.81	36.61	36.54	0.19	0.16
SAA intake (mg/day)	82.66^{B}	148.43^{A}	148.15^{A}	9.35	<0.01
		43 to 47 days of age			
BW (g)	3182.34^{B}	3410.14^{A}	3375.55^{A}	35.50	<0.01
ADG (g/day)	48.13	57.36	45.28	3.63	0.19
Feed intake (g/day)	225.26^{b}	256.66^{a}	234.81^{ab}	5.43	0.03
FCR	4.82	4.46	5.28	0.30	0.57
Protein intake (g/day)	38.27^{b}	43.61^{a}	39.90^{ab}	0.92	0.03
SAA intake (mg/day)	88.07^{B}	192.50^{A}	176.11^{A}	14.09	<0.01
		0 to 47 days of age			
Initial BW (g)	48.63	48.62	48.51	0.03	0.26
Final BW (g)	3182.34^{B}	3410.14^{A}	3375.55^{A}	35.50	<0.01
ADG (g/d)	66.68^{B}	71.52^{A}	70.79^{A}	0.76	<0.01
Feed intake (g/day)	150.65^{B}	162.07^{A}	159.40^{A}	1.63	<0.01
FCR	2.26	2.27	2.25	0.04	0.83
Protein intake (g/day)	28.28^{B}	30.32^{A}	29.91^{A}	0.29	<0.01
SAA intake (mg/day)	62.19^{B}	125.73^{A}	123.91^{A}	8.92	<0.01
Cumulative mortality rate (%)	2.00	1.00	1.00	0.57	0.75

ADG=average daily gain; BW=body weight; FCR=feed conversion ratio; SAA intake= total sulfur amino acids intake; DLM=DL-methionine; DL-MHA=DL-methionine hydroxy analogue.

$^{a, b}$ Means values in the same row with no common uppercase superscript differ significantly (P<0.05).

$^{A, B}$ Means values in the same row with no common uppercase superscript differ highly significantly (P<0.01).

The effects of Met sources on carcass quality are presented in Table 3. Dietary supplementation of Met (DLM or DL-MHA) significantly increased (P<0.05) pectoralis major when compared to the basal diet. However, there was no significant difference (P>0.05) in pectoralis minor, drumette and leg meat among the three groups. Adding DL-MHA to the diet resulted in more (P<0.05) skin with subcutaneous fat (breast meat area) compared to the basal diet. In contrast, supplemental Met (DLM or DL-MHA) significantly decreased (P<0.01) the abdominal fat content.

The effects of Met source on blood lipid profile and uric acid are presented in Table 4. Dietary supplementation of DL-MHA resulted in greater (P<0.05) levels of triglycerides, LDL and cholesterol in the blood compared to the DLM, and in addition to greater (P<0.05) levels of blood triglyceride and HDL when compared to the basal diet. Furthermore, the level of plasma uric acid was lower (P<0.05) with DLM supplementation than in the basal diet.

Discussion

Methionine is closely associated with lipid metabolism as this amino acid is considered to be one of the dietary lipotropes (Bunchasak, 2014). Methionine deficiency can reduce feed intake, resulting in high fat accumulation or high activities of lipogenetic enzymes in the liver (Rosebrough and Steele, 1985). In addition, methionine deficiency also causes an imbalance of amino acids, which results in a large negative impact on growth performance and carcass quality (Bunchasak, 2014). This is in agreement

with the results of the present study where ducks fed a methionine deficient diet showed lower feed intake, leading to higher abdominal fat accumulation and lower pectoralis major (breast meat) than those fed a methionine adequate diet (DLM and DL-MHA). The improvement in the performance of ducks fed Met (DLM or DL-MHA) was in agreement with previous studies (Xie et al., 2006; Jamroz et al., 2009; Kluge et al., 2016). The explanation is that this was due to the key roles of methionine in initiating amino acid for protein synthesis and as a principal biological methylating agent in the body (Bunchasak, 2014). As reviewed by Bunchasak (2009), the relative bioefficacy of DL-MHA compared with DLM in various animal species is from 65 to 90%. In the present study, based on 88% bioefficacy (wt/wt), there was no significant difference in growth performance between DLM and DL-MHA supplementation, which was in agreement with the report of Lu and Lai (2001) and Bunchasak, (2009). Therefore, it was concluded that DL-MHA can be used as 88% bioefficacy (wt/wt) of DLM in meat type duck at the level of the recommended requirements for the strain.

Table 3 Effect of methionine supplemented diet on carcass quality of ducks at 47 d of age (% of body weight).

Item	Experimental Diets			SEM	P-value
	Basal	DLM	DL-MHA		
Pectoralis major	16.35^{b}	17.51^{a}	17.95^{a}	0.25	0.02
Pectoralis minor	1.66	1.80	1.78	0.05	0.49
Drumette	13.35	12.34	12.13	0.28	0.17
Leg meat	20.87	19.99	19.95	0.21	0.13
Skin with subcutaneous fat	3.90^{b}	4.35^{ab}	4.75^{a}	0.13	0.02
Abdominal fat	1.23^{A}	0.85^{B}	1.00^{B}	0.05	<0.01

DLM=DL-methionine; DL-MHA=DL-methionine hydroxy analogue.
$^{a, b}$ Mean values in the same row with no common lowercase superscripts differ significantly (P<0.05).
$^{A, B}$ Means values in the same row with no common uppercase superscript differ highly significantly (P<0.01).

Table 4 Effect of methionine source on blood uric acid (mg/dL) and lipid profile (mg/dL) of ducks at 47 days of age.

Item	Experimental diets			SEM	P-value
	Basal	DLM	DL-MHA		
Triglyceride	34.44^{b}	37.88^{b}	50.29^{a}	2.62	0.02
Low-density lipoprotein	93.67^{a}	75.75^{b}	99.63^{a}	3.67	0.02
High-density lipoprotein	115.83^{b}	122.40^{ab}	137.71^{a}	4.90	0.04
Cholesterol	202.78^{ab}	168.75^{b}	216.57^{a}	7.62	0.03
Uric acid	4.95^{a}	3.13^{b}	4.42^{ab}	0.29	0.03

DLM=DL-methionine; DL-MHA=DL-methionine hydroxy analogue.
$^{a, b}$ Mean values in the same row with no common lowercase superscripts differ significantly (P<0.05).
$^{A, B}$ Means values in the same row with no common uppercase superscript differ highly significantly (P<0.01).

Since Met is generally required for protein synthesis, transmethylation and transsulfuration to cystine (Shoveller et al., 2005), dietary supplementation of Met increases the Met concentration in the body (Adeola, 2007), which supports the production of contractile protein (Bikker et al., 1994). In the present study, Met (DLM or DL-MHA) significantly increased breast meat (pectoralis major) but not the yield of leg meat. This was in agreement with studies in Muscovy ducks (Auvergne et al., 1991), Peking ducks (Wang et al., 2004, Xie et al., 2006) and broiler chickens (Rakangtong and Bunchasak, 2011). Therefore, it is stated that the breast meat of ducks is also more sensitive to SAA in the diet than that of other edible meat components.

There was no significant difference between the comparative effects of DLM and DL-MHA as Met sources on the breast meat yield and other carcass compositions. Similarly, Bunchasak and Keawarun (2006) reported that supplementation with DL-MHA improved the pectoralis major of broiler chickens as well as DLM supplementation when 88% bioefficacy (wt/wt) was used. As a result, it is suggested that supplementation with DL-MHA based on 88% bioefficacy (wt/wt) of DLM can promote protein accumulation in meat-type duck similar to supplementation with DLM when an appropriated SAA supply is offered.

Supplementation with Met has been reported to decrease abdominal fat in broiler chickens (Jensen et al., 1989, Vieira et al., 2004, Bunchasak and Keawarun, 2006) and meat-type duck (Xie et al., 2006), possibly because Met acts as a lipotropic agent through its role as a methyl donor, leading to the formation of carnitine and creatine (Kalinowski et al., 2003). The function of Met also plays a key role in lipogenesis and lipolysis, resulting in a reduction of abdominal fat accumulation (Takahashi and Akiba, 1995). Notably, the amount of subcutaneous fat (breast meat region) obtained in the present study increased when Met was supplemented, particularly with DL-MHA. This finding suggests that there are some different effects of SAA on the regulation of adipose tissue distribution between abdominal fat and subcutaneous fat. Therefore, regional measurements of fat accumulation should be an important issue from the viewpoint of the carcass quality of duck.

Among waterfowl, ducks have a thicker layer of subcutaneous fat to provide insulation and to tolerate low temperatures (Cherry and Morris, 2008). Consequently, skin with subcutaneous fat is greater than abdominal fat in ducks (Sakulthai, 2013). Furthermore, abdominal fat can be representative of

body fat in broiler chickens (Bunchasak and Keawarun, 2006), while the subcutaneous fat of duck has to be taken into account when fat accumulation is concerned (Bochno et al., 2013). Interestingly, the amount of subcutaneous fat of ducks fed Met was increased, possibly along with the following reasons: 1) high activity of fatty acid synthetase, which is the main lipogenic enzyme in the liver (Bunchasak et al., 1996); 2) high stimulation of storage of energy as fat accumulation (Smith et al., 1983); 3) high energy utilization due to an enhanced amino acid balance (Brody, 1994); and 4) increased feed intake due to adding Met producing maximum growth performance, which results in an increase in fatty synthesis. Likewise, DL-MHA seems to increase subcutaneous fat accumulation rather more than that of DLM. This phenomenon was in agreement with Esteve-Garcia and Llauradó (1997) and Bunchasak and Keawarun (2006), who reported that DL-MHA induced higher fat accumulation of broiler chickens compared to DLM.

Previous studies (Bunchasak and Silapasorn, 2005; Nukreaw et al., 2011) found that supplementation with Met increased the levels of liver triglyceride and serum LDL of poultry. In the present study, supplementation with DLM resulted in a lower level of LDL, whereas supplementation of DL-MHA led to greater levels of blood triglyceride and HDL. This finding indicates that DLM may potentially induce hypocholesterolemia, whereas the DL-MHA may result in hypercholesterolemia in meat-type ducks. Furthermore, the differences in the levels of triglycerides, LDL and cholesterol between DLM and DL-MHA may be due to DLM and DL-MHA having different effects on lipoprotein synthesis. This is in agreement with studies by Esteve-Garcia and Llauradó (1997), who also hypothesized that the effect of DLM on fat accumulation in broiler chickens may be different from that of DL-MHA. Bunchasak et al. (2012) found that DL-MHA increased the level of the estrogen hormone to a greater extent than DLM. The greater estrogen hormone is responsible for an increase in the hepatic synthesis of the lipo-protein, resulting in greater fat deposition (Scanes et al., 2004). Therefore, Met source may have different ways of influencing the function of hormones, which are involved in lipid metabolism.

Uric acid is a major end product of protein catabolism in poultry and its concentration in the blood is also in response to the contents of protein and amino acids in the diet (Miles and Featherston, 1974, Donsbough et al., 2010). The present study found that supplementing DLM to meet the requirements of ducks reduced plasma uric acid due to an improvement in the amino acids balance (Xie et al., 2004). However, the level of uric acid in ducks fed a diet supplemented with DL-MHA did not differ from that in ducks fed the basal diet. On the other hand, uric acid is an antioxidant agent and poultry can use it to scavenge free radical products from the metabolic process that results in prevention of DNA damage and lipid oxidation (Stinefelt et al., 2005). In broiler chickens, Yodseranee and Bunchasak (2012) reported that the levels of blood uric acid and taurine were increased by DL-MHA supplementation. Moreover, Swennen et al. (2011) found that DL-MHA supplementation partially prevented the growth-depressing effects of chronic heat exposure compared with DLM supplementation. Our results indicate that the degradation of DL-MHA and its derivatives in ducks may be different from that of DLM.

In conclusion, the supplementation of DL-MHA based on 88% bioefficacy of DLM (wt/wt) at the level of the recommended SAA requirements for the strain results in similar growth performance and carcass quality compared to the supplementation with DLM that give benefit to the production cost. Subcutaneous fat played a key role in fat accumulation, which can be used as fat index for meat-type duck. However, DL-MHA seemed to increase the amount of subcutaneous fat and the level of blood lipid profile compared to DLM. The underlying mechanism of some different effects between DL-MHA and DLM on the lipid metabolism in ducks should be further investigated.

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บทคัดย่อ

การเปรียบเทียบผลการเสริมดีแอล-เมทไธโอนีนและเมทไธโอนีนไฮดรอกซีอะนาลอกในอาหารต่อสมรรถภาพการผลิต การสะสมไขมันและไขมันในเลือดของเป็ดเนื้อ

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วัตถุประสงค์ของการศึกษานี้เพื่อเปรียบเทียบผลการเสริมดีแอล-เมทไธโอนีน (DLM) และเมทไธโอนีนไฮดรอกซีอะนาลอก (DL-MHA) ต่อการเจริญเติบโต คุณภาพซากและไขมันในเลือดของเป็ดเนื้อ โดยใช้เป็ดเพศผู้พันธุ์เชอร์รี่วัลเลย์จำนวน 300 ตัว แบ่งออกเป็น 3 กลุ่มๆ ละ 4 ซ้ำๆ 25 ตัว เป็ดแต่ละกลุ่มได้รับอาหารดังต่อไปนี้ 1) อาหารพื้นฐาน 2) อาหารพื้นฐาน + DLM และ 3) อาหารพื้นฐาน + DL-MHA จากการศึกษาพบว่าอาหารที่เสริม DLM และ DL-MHA มีผลเพิ่มน้ำหนักตัว ($P<0.01$) ปริมาณอาหารที่กิน ($P<0.01$) และเนื้อหน้าอก ($P<0.05$) แต่มีผลทำให้ไขมันช่องท้องลดลง ($P<0.01$) เมื่อเปรียบเทียบกับกลุ่มควบคุม การเสริม DL-MHA มีผลเพิ่มระดับไตรกลีเซอร์ไรด์ ($P<0.05$) Low-density lipoprotein ($P<0.05$) และคลอเลสเตอรอล ($P<0.05$) ในเลือดเมื่อเปรียบเทียบกับกลุ่มที่เสริม DLM อีกทั้งมีผลเพิ่มระดับไตรกลีเซอร์ไรด์ ($P<0.05$) และ High-density lipoprotein ($P<0.05$) เมื่อเปรียบเทียบกับกลุ่มควบคุม นอกจากนี้การเสริม DLM มีผลลดระดับกรดยูริก ($P<0.05$) ในพลาสมาเมื่อเทียบกับกลุ่มควบคุม จึงสรุปได้ว่าการเสริม DL-MHA สามารถส่งผลต่อการเจริญเติบโตได้เช่นเดียวกับการเสริม DLM แต่กลุ่มที่เสริม DL-MHA จะมีการสะสมไขมันในร่างกายและไขมันในเลือดสูงกว่ากลุ่มที่เสริม DLM อย่างไรก็ตามกลไกที่แตกต่างกันจากการเสริม DL-MHA และ DLM ต่อเมแทบอลิซึมของไขมัน ควรมีการศึกษาต่อไป

คำสำคัญ: ดีแอล-เมทไธโอนีน เมทไธโอนีนไฮดรอกซีอะนาลอก การสะสมไขมัน เป็ดเนื้อ สมรรถภาพการผลิต

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