Original Article

Re-estimation of supplemented methionine as total sulfur amino acid requirement for commercial male meat-type ducks

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Abstract

The total sulfur amino acid (TSAA) requirements of commercial meat-type ducks were investigated by feeding diets supplemented with graded levels of DL-methionine (DL-met) compared with the standard recommendation for the strain during 3 growth phases. Five hundred male White Pekin ducklings were divided into 4 treatments, each of which consisted of 5 replicates (25 each) using a completely randomized design. From the birds aged 1-9 and 10-16 days, TSAA deficit diet significantly depressed growth rate and feed intake (P<0.05). During 10-16 days of age, the growth rate of the birds fed TSAA at 110% of the commercial requirement was faster than that of the 100% group, with the increase in growth rate and feed intake paralleling the TSAA intake (P<0.01). No significant effects of the TSAA level on productive performance of the birds from age 17-47 days were found. At the age of 47 days, increasing the TSAA levels up to 120% tended to decrease abdominal fat content (P=0.08), and significantly decreased blood uric acid concentration (P<0.01). There were no significant differences in carcass components and lipid profile in the serum. The TSAA level for optimum growth rate and FCR in commercial meat-type ducks is 100-110% of the recommended level for the strain, except during 10-16 days of age when 110% is recommended.

Keywords: total sulfur amino acids, DL methionine, meat-type ducks

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Introduction

The world production of meat-type ducks has been increasing, as duck meat and products continue to show rewarding benefits. Although duck production has been ever-increasingly developed, scientific research on the nutrient requirements of meat-type ducks is still required to maximize productive performance of the birds. By supplementing feed-grade amino acids, it is possible to optimize the production, maintain animals' health, economize feed-cost, and minimize nitrogen pollution (Ishibashi and Yonemochi, 2002; Kim et al., 2006).

Methionine (Met) is considered as the first limiting amino acid in poultry. It is the initiating amino acid in the synthesis of virtually all eukaryotic proteins, and is closely involved in the pathways of methylation to give the ubiquitous methyl donor (S-adenosylmethionine; SAM) and transulfuration to transfer sulfur from Met to serine, resulting in cystein biosynthesis (Troen et al., 2003).

In poultry production, synthetic DL-Met as a feed supplement was first used in the late 1950s for improving production performance and immunity (Wu, 2013). Several investigators suggested that the optimal Met requirement of male White Peking ducks from hatching to the age of 21 days was 0.481% (Xie et al., 2004), and those from the ages of 22-49 days for maximum weight gain and breast meat yield were 0.377 and 0.379%, respectively (Xie et al., 2006). Due to the sparing effect between methionine (Met) and cysteine (Cys), Met+Cys or TSAA must be considered in feed formulation. The minimum recommended TSAA requirements for commercial strains are 0.90, 0.84, and 0.75% for starter 1, starter 2, and grower, respectively (Cherry Valley, 2004). Moreover, Bunchasak (2017) has recently suggested that the requirement of Met or TSAA for breast meat production is slightly higher than for body weight gain.

Successful management in meat-type poultry can be achieved through nutritional manipulations and strategic practices (Rath et al., 2000). Several factors affect the nutritional requirements of animals such as feed source, health status, environment, genetic production, age and physiological stress. Due to the rapid development of genetic potential of commercial meat-type duck, growth rate and feed utilization have improved. Unlike in broiler chickens, however, little research has mentioned the requirements for Met and TSAA in domesticated waterfowls. Under Thailand's environmental conditions, as a result of the modern genetic developments in meat-type duck, it is hypothesized that TSAA requirement may be higher than the standard recommendation for the strain.

Using productive performance and blood chemical profiles as the criterion, therefore, the aim of the present study was to gain further information on the effects of feeding diets supplemented with graded levels of DL-methionine (TSAA deficit, 110, and 120% TSAA) compared to the standard recommendations for the strain (100% TSAA) for 3 growth phases (age 1-9, 10-16, and 17-47 days) of commercial male meat-type ducks.

Materials and Methods

Experimental design and diets: A completely randomized design (CRD) was used in this study. Five hundred commercial male broiler ducks (Cherry Valley) were reared from age 1-47 days. The birds were divided into 4 treatments, each of which consisted of 5 replicates (25 each). The composition of experimental diets in a pellet form and the nutrient levels are shown in Table 1. Commercial phase feedings were divided as follows: during age 1-9 days (starter 1), 22% CP and 2,849 kcal/kg ME; during age 10-16 days (starter 2), 20% CP and 2,900 kcal/kg ME; and during age 17-47 days (grower), 18.50% CP and 2,899 kcal/kg ME. The experimental diets in a pellet form were formulated according to the nutrient requirement recommendation of the commercial strain, except for total sulfur amino acids.

Synthetic DL-methionine powder (Sumitomo Chemical, Japan) was supplemented in the 4 groups of experimental diets to determine the TSAA requirement. Four experimental diets were provided as follows: 1) diet with TSAA deficit, or no Met supplemented; 2) diet with 100% TSAA of the commercial recommendation; 3) diet with 110% TSAA of the commercial recommendation; and 4) diet with 120% TSAA of the commercial recommendation. The TSAA concentrations in the experimental diets are shown in Table 2. All diets were analyzed for protein, fat, calcium and total phosphorus according to the methods of the American Official Analytical Chemists (AOAC, 1990). The amino acid composition of the basal diets in all periods was determined using an amino acid analyzer technique (model 835-50, Hitachi, Japan).

Management of experimental animals: The animals were kept in an evaporative cooling housing system in 20 floored pens (25 birds/pen; 5 replicates/treatment; 0.24 m^2/bird). The floor of each pen was littered with rice polish, and all pens were equipped with a nipple drinker line (8 nipples per pen) and a tube feeder. Water and pelleted feed were free-accessed. Lighting program was as follows: during age 1-3 days, 24 hours of lighting; during age 4-9 days, 18 hours of lighting day by day; and during age 10-47 days, 18 hours of lighting. The birds were maintained and treated in compliance with the standards for the human treatment of animals, and care was taken to minimize the number of animals used. The experimental design and procedures were approved and conducted at Kasetsart University's Luang Suwanvajokkasikij Poultry Farm, Bangkok, Thailand.

Data collection: Normal behavior, health and bird mortality among the treatments were observed and recorded. Average daily gain (ADG), feed intake, feed conversion ratio (FCR), and TSAA intake were determined. The birds were weighed as a whole pen group of pen at age 9, 16, and 47 days. Feed consumption during 1-9, 10-16, and 17-47 days of age was determined.

At the age of 47 days, two birds from each replicate (8 birds/treatment) were deprived of feed but still had free access to water 12 h before being sacrificed and further processed. The birds were randomly chosen, and blood samples were taken from the wing vein. Serum samples were obtained by centrifugation at 1,500× g for 15 min, and stored at -20°C until analysis. Blood chemical profiles (uric acid, triglycerides and cholesterol) were determined using colorimetric automated clinical analyzer (RX Daytona, Randox Laboratories, UK).

The birds were sacrificed using asphyxiation under less than 2% oxygen using CO_2 replaced air for 2 min. Carcasses, some commercial cuts (breast meat, thigh and fillet), abdominal fat and liver were processed and weighed (Bunchasak et al., 2006).

Table 1 Composition and nutrient concentration of basal diet (as fed) with 100% total sulfur amino acids (TSAA) of the commercial recommendation

Items	Starter 1 (1-9 days)	Starter 2 (10-16 days)	Grower (17-47 days)
Ingredient (%)			
Corn	30.00	30.00	30.00
Broken rice	3.55	12.97	10.66
Rice bran	12.92	2.71	9.02
Defatted rice bran	-	-	0.98
Wheat bran	14.56	20.00	20.00
Rice bran oil	4.00	4.00	4.00
Soybean meal	30.44	25.67	21.33
Calcium carbonate	1.67	1.63	1.98
Monodicalcium phosphate	1.58	1.73	0.90
Salt	0.42	0.42	0.42
Choline chloride	0.08	0.08	0.08
Mycotoxin binder	0.05	0.05	0.05
DL-methinone	0.23	0.23	0.17
L-lysine HCL	0.26	0.23	0.14
L-threonine	0.08	0.12	0.07
Antioxidant	0.01	0.01	0.01
Premix[A]	0.15	0.15	0.15
		Nutrients by calculation (analysis)[B]	
Metabolizable energy (kcal/kg)	2849	2900	2899
Crude protein (%)	22.00 (21.90)	20.00 (19.80)	18.50 (18.40)
Crude fat (%)	7.71	6.38	7.27
Crude fiber (%)	4.07	3.71	4.07
Lysine (%)	1.35 (1.33)	1.17 (1.16)	1.00 (0.98)
Methionine (%)	0.55 (0.53)	0.52 (0.49)	0.45 (0.42)
TSAA (Met + Cys) (%)	0.90 (0.85)	0.84 (0.81)	0.75 (0.71)
Threonine (%)	0.90 (0.88)	0.85 (0.82)	0.75 (0.70)
Calcium (%)	1.00	1.00	1.00
Available phosphorus (%)	0.50	0.50	0.35

[A] Vitamin and mineral premix content (per kg of total diet): vitamin A 12,000 IU, vitamin D 3,000 IU, vitamin E 20 IU, vitamin K 2 mg, thiamin 2 mg, riboflavin 8 mg, pyridoxine 4 mg, niacin 25 mg, cobalamin 0.02 mg, panthothenic 20 mg, nicothenic 20 mg, folic acid 3 mg, biotin 0.2 mg, choline chloride 1,000 mg, iron 60 mg, manganese 80 mg, zinc 60 mg, selenium 0.2 mg, iodine 0.5 mg, copper 8 mg, iodine 0.5 mg
[B] The values in parenthesis are based on chemical analysis.

Table 2 Dietary total sulfur amino acid (TSAA) concentration in experimental diets

Treatments	TSAA concentration (% of diet)		
	Starter 1	Starter 2	Grower
(1) TSAA deficit of commercial recommendation (no Met supplemented)	0.67	0.61	0.58
(2) 100% TSAA of commercial recommendation[A]	0.90	0.84	0.75
(3) 110% TSAA of commercial recommendation[A]	0.99	0.92	0.83
(4) 120% TSAA of commercial recommendation[A]	1.08	1.01	0.90

[A] Based on the TSAA supplemented level of the commercial recommendation

Statistical analyses: Data were analyzed by the 2-way ANOVA in a completely randomized design, using the PROC GLM procedure of the SAS software, version 2016. In the analysis, pen means were defined as the experimental unit. Differences among the treatments were tested using Duncan's multiple range tests. Quadratic and linear models were analyzed using the REG procedure of the SAS software. Probability values of $P \leq 0.05$ were considered statistically significant.

Results

Effects of the increase in TSAA level in the diet on growth performance of the ducks are presented in Table 3. Increasing the dietary TSAA contents significantly increased TSAA intake of the ducks from age 1 to 47 days, and sufficient TSAA (100-120%) improved growth rate of the ducks from age 1-16 days compared to the TSAA deficit group ($P<0.01$), but not for the ducks from age 17-47 days. TSAA deficiency significantly depressed the feed intake and growth rate of the ducks from age 1-9 and 10-16 days (P<0.01). Increasing TSAA to above the level recommended for the strain (110% and 120% TSAA groups) did not significantly promote growth performance, except for the body weight of the ducks from age 10-16 days which was significantly heavier than that of the 100% TSAA group (P<0.05). The FCR of the ducks from age 10-16 days was characterized with a quadratic fashion by the increased TSAA levels (P<0.05), but showed no differences from that of the birds of other ages. Overall, during the experimental period (age 1-47 days), the supplementation of TSAA to meet or exceed the recommendation for the strain (100-120% TSAA) significantly enhanced the body weight of the ducks, while the high TSAA supplementation (120% TSAA) slightly improved the FCR.

The effects of TSAA levels on carcass characteristics are shown in Table 4. No significant effects of TSAA in the diets were observed on the weights of the eviscerated carcass, breast meat, thigh, fillets, and liver. However, the weight of abdominal fat showed a tendency to decrease when Met was supplemented.

The blood chemical profiles are shown in Table 5. Serum uric acid levels were decreased linearly as the concentrations of dietary TSAA increased (P<0.01). The concentration of uric acid in the blood of birds from the TSAA deficit treatment was significantly higher than that from the 120% TSAA group (P<0.01). However, there were no significant effects of TSAA on blood lipid profiles.

Table 3 Effect of total sulfur amino acids (TSAA) on growth performance of meat-type ducks from age 1-47 days

TSAA (% of commercial level)	Growth performance				
	BWG (g)	ADG (g)	Feed Intake (g)	FCR	TSAA intake (g/bird)
			1-9 d		
TSAA deficit	204.63[b]	22.74[b]	230.00[b]	1.12	1.45[d]
100	300.37[a]	33.38[a]	358.00[a]	1.19	3.22[c]
110	297.18[a]	33.02[a]	352.00[a]	1.18	3.48[b]
120	298.74[a]	33.20[a]	352.00[a]	1.17	3.80[a]
SEM	9.59	1.06	12.71	0.01	0.21
Linear regression	<0.01	<0.01	<0.01	0.14	<0.01
Quadratic regression	<0.01	<0.01	<0.01	0.13	<0.01
			10-16 d		
TSAA deficit	477.43[c]	68.21[c]	643.00[b]	1.35[b]	3.92[d]
100	521.46[b]	74.50[b]	745.28[a]	1.43[a]	6.26[c]
110	561.05[a]	80.15[a]	765.44[a]	1.37[ab]	7.04[b]
120	565.37[a]	80.77[a]	761.04[a]	1.35[b]	7.69[a]
SEM	8.97	1.28	12.78	0.01	0.33
Linear regression	<0.01	<0.01	<0.01	0.43	<0.01
Quadratic regression	0.03	0.03	<0.01	0.01	<0.01
			17-47 d		
TSAA deficit	2447.25	78.94	5874.10	2.40	34.07[c]
100	2529.73	81.60	6215.90	2.45	46.62[b]
110	2436.78	78.61	5854.10	2.40	48.60[ab]
120	2465.43	79.53	5765.80	2.39	51.89[a]
SEM	16.32	0.53	85.56	0.03	15.89
Linear regression	0.18	0.78	0.37	0.41	<0.01
Quadratic regression	0.39	0.39	0.21	0.39	0.01
			1-47 d		
TSAA deficit	3129.31[b]	68.58[b]	6747.20	2.16	39.44[c]
100	3351.56[a]	73.31[a]	7319.20	2.18	56.10[b]
110	3295.01[a]	70.11[a]	6972.20	2.12	59.12[ab]
120	3329.53[a]	70.84[a]	6878.80	2.07	63.38[a]
SEM	2482	4.63	89.29	0.03	2.15
Linear regression	<0.01	<0.01	0.95	0.17	0.01
Quadratic regression	0.01	0.01	0.06	0.45	0.01

[a, b, c] Values within the same column with different superscript letters are significantly different (P<0.05).

Table 4 Effect of total sulfur amino acids (TSAA) on carcass yields of meat-type ducks at age 17-47 days

TSAA (% of commercial level)	Carcass yield at age 47 days (% of live weight)					
	Carcass	Breast meat	Thigh	Fillet	Abdominal fat	Liver
TSAA deficit	82.00	13.64	17.29	1.40	1.01	1.92
100	80.60	13.63	16.42	1.40	0.80	2.07
110	82.00	14.37	16.54	1.55	0.82	2.08
120	83.20	13.70	17.05	1.48	0.82	2.12
SEM	0.01	0.23	0.21	0.03	0.04	0.05
Linear regression	0.51	0.68	0.73	0.10	0.08	0.21
Quadratic regression	0.45	0.50	0.11	0.47	0.14	0.59

Table 5 Effect of total sulfur amino acids (TSAA) on blood chemical profiles at age 17-47 days

TSAA (% of commercial level)	Blood chemical profiles at age 47 days				
	Uric acid (mg/dL)	Triglyceride (mg/dL)	HDL-C (mg/dL)	LDL-C (mg/dL)	Cholesterol (mg/dL)
TSAA deficit	4.30[a]	38.80	127.40	87.60	208.60
100	3.69[ab]	38.80	103.20	76.86	168.60
110	2.97[ab]	47.40	129.40	99.80	199.60
120	1.83[b]	36.00	130.20	94.00	192.20
SEM	0.33	2.49	6.15	4.59	7.54
Linear regression	< 0.01	0.99	0.53	0.31	0.79
Quadratic regression	0.34	0.27	0.32	0.79	0.28

[a, b, c] Values within the same column with different superscript letters are significantly different (P<0.05).

Discussion

An improved growth rate of the birds was observed via increased bodyweight gain from age 1-9 (by 46.79%), 10-16 days (by 9.22%) and 17-47 days (by 3.37%) when the TSAA content was increased from the deficit level (no methionine supplemented) to 100% of the recommended level for the strain. The supplementation of Met also increased the feed intake of the birds from age 1-16 days, but not from age 17-47 days. Waldroup et al. (1976) stated that if a slight amino acid deficit existed, the chick might attempt to compensate by consuming more feed, as a result, growth might be at a maximum or normalized rate. Due to amino acid imbalance, Bunchasak (2017) has stated that excess or low level of TSAA in the diet largely impacts on feed intake of poultry. In the current study, therefore, the birds during age 1-16 days fed TSAA deficit showing a depressed feed intake may be caused by the imbalance of amino acid pattern. It was shown that the degree of sensitivity to amino acid imbalance or deficiency was less during age 17-47 days. The post-hatching and early growth during periods of avian species are considered critical as a prelude to muscle cell proliferation and the growth of muscle and feathers in later developmental stages. Accordingly, Rakangtong and Bunchasak (2011) found that TSAA supplementation brought more positive responses in young (age up to 21 days) broiler chicks than in older ones (age 22-42 days). The first two measurement periods (age 1-9 and 10-16 days) of ducks in this study provided strong evidence for such conclusion.

Age played a major role in influencing the amino acid contents, as demonstrated by the Met content of the carcass increasing between day 1 and day 14 before decreasing thereafter (Stilborn et al., 2010). The present study also showed pronounced differences in the growth of ducks fed 100-120% TSAA compared with TSAA deficit diets from age 1-9 and 10-16 days. Accordingly, Xie et al. (2006) found that there were no effects of added dietary Met on feed intake and FCR among experimental male White Pekin ducks from age 21-49 days. Adding excess Met to diets always leads to plasma imbalance of amino acids and feed intake suppression, affecting growth performance, as reported by several researchers (Elkin et al., 1986; Frontiera et al., 1994; Harper et al., 1970; Rakangtong and Bunchasak, 2011; Xie et al., 2004). However, the current study indicates that the excess TSAA supplementation (120% of the recommended TSAA level for the strain) did not negatively affect feed intake and growth rate.

The current results were in agreement with those of Jamroz et al. (2009), who reported that FCR of ducks at age 1-42 days was not influenced by Met supplementation. In the current study, the FCR of the birds from age 1-47 days was not influenced by the varying TSAA levels, although it was slightly improved with the increased TSAA levels. However, during age 10-16 days, the FCR from the varying TSAA levels resulted in a quadratic effect (P<0.05), starting from 1.35 to 1.43 (from TSAA deficit to 100% TSAA diets) before changing from 1.37 to 1.35 (from 110 to 120% TSAA diets). Therefore, during this period, the 100% TSAA level recommended by the commercial strain may be sub-marginal to requirements because this deficiency can result in birds over-consuming feed to satisfy their appetite for amino acids (Lipstein et al., 1975; Smith and Austic, 1978; Summers et al., 1992) which can subsequently increase the FCR. Thus, the requirement of TSAA for optimal FCR may be higher than that recommended for the strain during 10-16 days of age.

There were no significant differences in the carcass and breast meat improvement as a result of the increased Met levels, albeit there were some tendencies among the treatment groups (Jamroz et al., 2009). Failures to promote breast meat yields through the supplementation of essential amino acids have also been recorded (Summers et al., 1992). However, other studies mentioned expected positive effects of Met supplementation on breast meat yield of growing ducks and broiler chickens (Hickling et al., 1990; Moran, 1994; Rakangtong and Bunchasak, 2011; Schutte and Pack, 1995; Xie et al., 2006; Zhai et al., 2012). Enhancing abdominal fat accumulation due to Met deficits was reported (Mendonca and Jensen, 1989; Moran, 1994). In the present study, the abdominal fat weights in the ducks showed a tendency to decrease when the TSAA levels were increased linearly in the diets (P=0.08), although blood lipid profiles were not affected. Therefore, in duck, fat accumulation may be rather more sensitive to Met supplementation than meat yield production.

It was clear that serum uric acids were significantly decreased by the linear increase in TSAA concentration in the diets. In general, blood urea and uric are commonly used for evaluating the effect of amino acids in diet on nitrogen balance of mammal and poultry, respectively (Bunchasak, 2017). In pigs, Lewis et al. (1980) and Feng et al. (2006) reported that when the limiting amino acid (Lys or Met) was supplemented, the concentration of blood urea would be decreased continuously until the limiting amino acid reached the requirement. In poultry, blood uric acid can be used as an indicator of amino acid (AA) utilization in broilers fed amino acid adequate and amino acid deficient diets (Donsbough et al., 2010). Accordingly, in present study, the blood uric acid concentration of the ducks was decreased by the increased TSAA level, and there was a positive relationship between the serum uric acids and the FCR (r=0.92). It is assumed that the supplementation of Met to meet TSAA at 120% of the commercial recommendation can improve amino acid balance in ducks.

In conclusion, the TSAA requirement of commercial meat-type ducks is critical at age 1-16 days, at which their growing potential is developed. The TSAA level for optimum growth rate and FCR in commercial meat-type ducks is 100% of the recommended level for the strain, except during 10-16 days of age when 110% is recommended.

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บทคัดย่อ

การประเมินทบทวนค่าความต้องการกรดอะมิโนที่มีกำมะถันเป็นองค์ประกอบของเป็ดเนื้อสายพันธุ์ทางการค้าเพศผู้

เกรียงไกร ประการแก้ว[1,4] เกียรติทวี ชูวงศ์โกมล[2] บุญอ้อม โฉมที[3]
เชาว์วิทย์ ระฆังทอง[1] ชัยภูมิ บัญชาศักดิ์[1]*

ศึกษาความต้องการกรดอะมิโนที่มีกำมะถันเป็นองค์ประกอบ (TSAA) ของเป็ดเนื้อจากการเสริม DL-methionine โดยให้ระดับ TSAA สูงขึ้นเทียบตามระดับสายพันธุ์ 3 ระยะ ใช้เป็ดเนื้อพันธุ์ไวท์ปักกิ่งเพศผู้จำนวน 500 ตัว แบ่งออกเป็น 4 กลุ่ม ๆ ละ 5 ซ้ำ ๆ ละ 25 ตัว พบว่าในช่วงอายุ 1-9 วัน และ 10-16 วัน เป็ดกลุ่มที่ขาด TSAA มีอัตราการเติบโตและการกินได้ต่ำกว่ากลุ่มอื่นอย่างมีนัยสำคัญ (P<0.05) เป็ดช่วงอายุ 10-16 วันที่ได้รับ TSAA 110 เปอร์เซ็นต์ของคำแนะนำตามสายพันธุ์มีอัตราการเติบโตเร็วกว่ากลุ่มที่ได้รับ TSAA 100 เปอร์เซ็นต์อย่างมีนัยสำคัญ (P<0.01) ขณะที่ระดับ TSAA ในอาหารทดลองไม่มีผลต่อการเจริญเติบโตของเป็ดในช่วงอายุ 17-47 วัน เมื่ออายุ 47 วัน TSAA 120 เปอร์เซ็นต์ของคำแนะนำตามสายพันธุ์มีแนวโน้มทำให้ปริมาณไขมันในช่องท้องของเป็ดลดลง (P=0.08) และความเข้มข้นของกรดยูริกในเลือดลดลงอย่างมีนัยสำคัญ (P<0.01) แต่ไม่พบความแตกต่างอย่างมีนัยสำคัญของคุณลักษณะของซากและค่าไขมันจากโลหิตระหว่างกลุ่มทดลอง จากการทดลองนี้สรุปได้ว่า ระดับ TSAA ที่เหมาะสมต่ออัตราการเติบโตและอัตราการแลกอาหารเป็นน้ำหนักตัวสำหรับเป็ดเนื้อคือ 100 เปอร์เซ็นต์ของคำแนะนำตามสายพันธุ์ ยกเว้นในช่วงอายุ 10-16 วัน ที่ความต้องการเท่ากับ 110 เปอร์เซ็นต์ของคำแนะนำตามสายพันธุ์

คำสำคัญ: กรดอะมิโนที่มีกำมะถันเป็นองค์ประกอบทั้งหมด DL-methionine เป็ดเนื้อ

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