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Effects of Dietary Energy and Methionine Sources on Productive Performance and Carcass Yield in Broiler Chickens

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ABSTRACT

An experiment was conducted to determine the effects of two dietary energy sources (corn and cassava) and three types of dietary methionine (Met) supplementation (without methionine supplementation, liquid DL-methionine hydroxy analog-free acid (LMA) supplementation and dry DL-methionine (DLM) supplementation) on the growth performance and carcass yield of broiler chicks during 0-6 weeks of age. The experiment was a completely randomized design in a 2 × 3 fractional factorial. Nine hundred commercial male broiler chicks (Ross strain) were divided into six groups, and each group consisted of six replicates of 25 chicks each. The chicks were kept in floor pens, and water and feed were supplied *ad libitum* throughout the experimental period. The six experimental diets were: 1) corn-soybean diet deficient in methionine, 2) corn-soybean diet supplemented with DLM, 3) corn-soybean diet supplemented with LMA, 4) cassava-soybean diet deficient in methionine, 5) cassava-soybean diet supplemented with DLM and 6) cassava-soybean diet supplemented with LMA. The experiment assumed that 100 units of liquid LMA could be replaced by 88 units of DLM. Weight gains, feed conversion ratio (FCR) and average daily gain (ADG) in chicks fed the diets supplemented with LMA or DLM were significantly greater than those in chicks fed the methionine-deficient diets (P<0.05). The weights of the eviscerated carcass, pectoralis major, pectoralis minor and wings were increased by DLM and LMA supplementation (P<0.05). Dietary energy sources analysis indicated that the meat yield of chicks fed the cassava-soybean diet was lower than for chicks fed the corn-soybean diet, while the abdominal fat level was higher. The results indicated that chicks fed the cassava-soybean base diet showed lower productive performance than chicks fed the corn-soybean base diet. The effect of methionine source (DLM and LMA) on the growth performance and carcass yield of chicks was not significantly different. In conclusion, adding methionine could prevent the negative impact of amino acid imbalance and improve the energy utilization of chicks fed on a diet based on cassava-soybean.

Keywords: corn, cassava, methionine sources, carcass yield, broiler chicken

INTRODUCTION

Corn is a major source of energy in broiler diets. In recent years, the price of corn has dramatically increased; therefore, an alternative energy source is sought. Cassava root meal is a primary source of carbohydrate and can replace corn as an energy source for pig and poultry diets (Khajarern and Khajarern, 1985). However, high fiber and low protein are limiting factors of cassava

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as an energy source. When cassava is used as an energy source, generally, a greater amount of supplemental protein source, such as soybean meal, fishmeal and synthetic amino acids (particular methionine), is required.

Dry DL-methionine (DLM) and liquid DL-methionine hydroxy analog-free acid (LMA) are commonly used in poultry diets. The average relative bioavailability of LMA compared with DLM in various animal species is approximately 65-90% (Reid *et al*., 1982; Van Weerden *et al*., 1983; Scott, 1987; Harms and Russell 1994; Hoehler and Hooge 2003). Knight and Dibner (1984) reported differences in the mechanism of absorption for LMA and DLM, although these two compounds are absorbed at quite similar rates, which vary according to the location in the small intestine. Moreover, they reported that LMA is absorbed rapidly in the proximal loop of duodenum and mid-jejunum, whereas L-Methionine is absorbed rapidly in the ileum. Thus, it is hypothesized that when corn is replaced by cassava as an energy source, supplementation using different sources of methionine (DLM and LMA) will produce different effects on the growth performance of broiler chicks.

Therefore, the study was conducted to investigate the effects of supplementing LMA and DLM in different dietary energy sources (corn-soybean and cassava-soybean diet) on the growth performance, carcass yield, abdominal fat, liver fat and triglyceride content of male broiler chickens from 0 to 6 weeks of age.

MATERIALS AND METHODS

The experimental design was a completely randomized design in a 2 × 3 fractional factorial arrangement. The main effects were dietary energy sources (ES; corn and cassava) and dietary methionine supplementations (MS; methionine-deficient (MD), DLM and LMA). A total of 900 commercial male broiler chicks (Ross strain) was used and divided into six treatments, with each treatment consisting of six repetitions of 25 chicks each. The chicks were housed under an evaporative cooling system. Lighting and vaccinations were managed according to standard commercial practice. Water and feed were offered *ad libitum* throughout the experiment.

Table 1 Methionine sources and corn starch supplements to corn-soybean diet[1].

	MD		DLM		LMA	
	Starter	Grower	Starter	Grower	Starter	Grower
Supplementary methionine (mg/100 g)	0	0	464	369	527	419
Corn starch (mg/100 g)	464	369	0	0	0	0

[1] The values of methionine were added to the basal diets. DLM = dry DL-methionine; LMA = liquid DL-methionine hydroxy analog-free acid; MD = Methionine deficient.

Table 2 Methionine sources and corn starch supplements to cassava-soybean diet[1].

	MD		DLM		LMA	
	Starter	Grower	Starter	Grower	Starter	Grower
Supplementary methionine (mg/100 g)	0	0	526	437	598	496
Corn starch (mg/100 g)	526	369	0	0	0	0

[1] The values of methionine were added to the basal diets. DLM = dry DL-methionine; LMA = liquid DL-methionine hydroxy analog-free acid; MD = Methionine deficient.

Two sources of methionine (DLM and LMA) were used in order to compare their effects. As the bioefficacy of LMA to DLM ratio was set at 88%, the amount of supplemental LMA was 1.136-fold higher than that of DLM. The basal diets in mash form (TSAA-deficient; approximately 58% of requirement during starter period and approximately 47% of requirement during grower period) were supplemented with DLM and LMA to meet the requirements of broiler chickens for total sulfur amino acid (TSAA). The feed formula and nutrients contained in the basal diet are shown in Table 3.

Table 3 Composition and nutrient levels of basal diets.

	Starter diet (Week 0 to 3)		Grower diet (Week 3 to 6)	
	Corn	Cassava	Corn	Cassava
Ingredient (%)				
Corn	57.95	-	64.57	-
Cassava	-	46.47	-	51.67
Soybean meal	27.17	34.01	23.88	31.55
Full-fat SBM	7.00	7.00	5.00	5.00
Rice bran oil	2.60	7.64	1.81	7.47
L-lysine	0.48	0.36	0.37	0.23
L-threonine	0.18	0.16	0.12	0.10
MDCP 21%	2.37	2.40	2.11	2.15
Lime stone	1.29	0.95	1.16	0.79
Salt	0.20	0.18	0.30	0.30
Premix[1]	0.18	0.18	0.18	0.18
Antioxidant	0.13	0.13	0.13	0.13
Nutrients by calculation (analysis)[2]				
ME for poultry , kcal/kg	3170.00	3170.00	3170.00	3170.00
Crude protein, %	21.00	21.00	19.00	19.00
Crude fat, %	6.51	9.80	5.54	9.24
Crude fiber, %	3.00	4.50	2.87	4.65
Lysine, %	1.44 (1.46)	1.44 (1.47)	1.23 (1.23)	1.23 (1.25)
Arginine, %	1.35 (1.32)	1.45 (1.37)	1.20 (1.22)	1.31 (1.17)
Methionine, %	0.29 (0.26)	0.26 (0.24)	0.28 (0.24)	0.24 (0.29)
Met + Cys, %	0.62 (0.63)	0.56 (0.67)	0.58 (0.57)	0.51 (0.45)
Threonine, %	0.93 (0.86)	0.93 (0.83)	0.80 (0.74)	0.80 (0.69)
Calcium, %	1.00	1.00	0.90	0.90
Available P, %	0.50	0.50	0.45	0.45

[1] Vitamin & mineral premix content; Composition per kg: Vitamin A 12,000 IU; Vitamin D 3,000 IU; Vitamin E 15 IU; Vitamin K 1.5 mg; Thiamine 1.5 mg; Riboflavin 5 mg; Pyridoxine 2 mg; Niacin 25 mg; Vitamin B_{12} 0.01 mg; Pantothenic acid 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 0.50 mg; Selenium 0.1 mg; Cobalt 0.1 mg.

[2] The values in parentheses are based on chemical analysis.

ADG, feed intake and FCR were determined. The chicks were weighed at age 3 and 6 wk, and feed intake was measured daily. FCR was calculated as feed intake (g) divided by body weight gain (g). All pens were checked daily for deaths.

At the end of the experiment, after overnight feed deprivation, six chicks with body weights close to the mean of the group were chosen from each group and killed. Carcass yield and abdominal fat weight were evaluated. The eviscerated carcasses, viscera, breast meat (pectoralis major and minor) and abdominal fat were weighed. According to Cabel *et al*. (1987), the fat surrounding the gizzard was also classified as abdominal fat.

All data were statistically analyzed using two-way ANOVA, using two energy sources and three dietary methionine supplementations. The differences between the means of groups were assessed using Duncan's new multiple range test (Duncan, 1955). Statistical significance was accepted at a *P*-value less than or equal to 0.05.

Table 4 Effect of dietary energy and methionine source on growth performance of broiler chicks from 0 to 3 and 3 to 6 weeks of age.

Items	Weight Gain (g)	ADG (g)	Feed intake (g)	FCR
	Starter period (0 to 3 wk)			
Energy source				
Corn	709^{A}	33.76^{A}	1020^{B}	1.44^{B}
Cassava	682^{B}	32.47^{B}	1035^{A}	1.52^{A}
Dietary methionine				
MD	637^{b}	30.36^{b}	1004^{b}	1.58^{a}
DLM	718^{a}	34.18^{a}	1039^{a}	1.45^{b}
LMA	730^{a}	34.80^{a}	1037^{a}	1.42^{b}
Statistic				
SEM	8.28	0.39	4.66	0.01
ES	*	*	*	*
MS	*	*	*	*
ES×MS	NS	NS	NS	NS
	Grower period (3 to 6 wk)			
Energy source				
Corn	1791	85.28	3134^{B}	1.76^{B}
Cassava	1741	82.92	3304^{A}	1.91^{A}
Dietary methionine				
MD	1531^{b}	72.93^{b}	3050^{b}	1.99^{a}
DLM	1867^{a}	88.91^{a}	3306^{a}	1.77^{b}
LMA	1899^{a}	90.45^{a}	3299^{a}	1.73^{b}
Statistics				
SEM	32.34	1.54	33.88	0.02
ES	NS	NS	*	*
MS	*	*	*	*
ES×MS	NS	NS	NS	NS

^{A,B,a,b} Means within a column with different superscripts for each parameter differ significantly ($P<0.05$); SEM = standard error of the mean; * = $P<0.05$; NS = not significant ($P>0.05$).

RESULTS

Growth performance and carcass yield

Table 4 presents the effects of the experimental diets on the growth performance of broiler chicks aged from 0 to 3 wk and 3 to 6 wk. During the starter period (0 to 3 wk), there was no interaction between ES and MS (P>0.05) for weight gain, ADG, feed intake and FCR. Supplementation of diet with DLM or LMA significantly improved the weight gain of chicks (P<0.05) in both dietary energy sources. Weight gain was increased by 12.71 and 14.59 % when supplemented with DLM and LMA, respectively. During the growing period, no interaction effects between the two factors were detected. Feeding a cassava-soybean diet increased feed intake and FCR compared to a corn-soybean diet.

Growth performance during 0 to 6 wk is shown in Table 5. No interaction between dietary energy sources and methionine supplementations was found for weight gain, FCR, ADG and feed intake. In both dietary energy sources, the weight gains of chicks receiving diets supplemented with DLM or LMA were greater than those of chicks fed methionine-deficient diets (P<0.05). Furthermore, under the methionine-deficient condition, the chickens fed the corn-soybean diet showed better growth performance than chickens fed the cassava-soybean diet. The addition of DLM or LMA to both energy sources significantly increased ADG. Carcass components at 6 wk are shown in Table 6. The weights of eviscerated carcasses, pectoralis major, pectoralis minor and wings of chicks fed the corn-soybean diets were higher than those of chicks fed the cassava-soybean diets (P<0.05).

DISCUSSION

The study showed that there was no significant difference in weight gain between chicks fed the cassava-soybean diets and chicks fed the corn-soybean diets under the methionine-supplemented condition. However, feed intake was increased for chicks fed the cassava-soybean diets supplemented with methionine, and this coincided with the fact that the FCR of chicks fed the cassava-soybean diets was poorer than that of chicks fed corn-soybean diets under the methionine-supplemented condition. Therefore, the higher feed intake was related to the higher crude fiber levels of the diets associated with the corresponding decrease in the true digestibility of

Table 5 Effect of dietary energy and methionine source on growth performance of broiler chicks from 0 to 6 weeks of age.

Methionine	Weight gain (g)			Feed intake (g)			FCR		
	Corn	Cassava	Mean	Corn	Cassava	Mean	Corn	Cassava	Mean
MD	2247	2091	2169^{b}	4004	4104	4054^{b}	1.78	1.96	1.87^{a}
DLM	2582	2588	2585^{a}	4205	4487	4346^{a}	1.62	1.73	1.68^{b}
LMA	2670	2590	2630^{a}	4251	4423	4337^{a}	1.59	1.70	1.65^{b}
Mean	2500^{A}	2423^{B}	2461	4153^{B}	4338^{A}	4246	1.67^{B}	1.80^{A}	1.73
Statistics									
SEM		39.32			36.80			0.02	
ES		*			*			*	
MS		*			*			*	
ES×MS		NS			NS			NS	

A,B,a,b Means within row and column with different superscripts for each parameter differ significantly (P<0.05); SEM = standard error of the mean; * = P<0.05; NS = not significant (P>0.05).

the diets. Adama *et al*. (2007) reported that an increase in the crude fiber content in the diet of broilers caused a significant decline in the digestibility coefficient of the dry matter and other nutrients and led to increased feed intake. In addition, increasing feed intake due to supplementation of DLM and LMA may have been caused by an improvement in the balance of amino acid in the diet. In the current study, supplementation of methionine increased the TSAA:lysine ratio in the diet from 0.41 to 0.75 in the starter period and from 0.43 to 0.76 in the grower period. Accordingly, Powell *et al*. (2009) reported that increasing the TSAA:lysine ratio in the corn-soybean diet from 0.51 to 0.76 increased the average daily gain of broiler chickens.

The carcass yields of chicks fed the corn-soybean diets were higher than those of chicks fed the cassava-soybean diets, although there was no difference in the live weight. Furlan *et al*. (2004) considered that a deficiency in protein (amino acids) consumption was the fundamental cause of decreasing carcass yields, because protein is closely related to the synthesis of structural tissues. In the current experiment, carcass yields were higher and abdominal fat pads were less than in chicks fed corn-soybean diets compared to cassava-soybean diets. Kidd *et al*. (1996) suggested that the increased fat deposition of broilers receiving a low protein (amino acids) diet may have been the result of lower energy expenditure and less amino acid nitrogen catabolism into uric acid. Therefore, it may be implied that the degree of amino acid imbalance in the cassava-soybean diet deficient in methionine (0.24% Met) was more serious than that in the corn-soybean diet (0.28% Met). In agreement with Bunchasak and Keawarun, (2006), the current study found that supplementation of methionine in methionine-deficient diets significantly reduced fat deposition in the broiler carcass. The positive effect on breast meat of adding methionine to the diet was confirmed in the current experiment, as the addition of methionine promoted higher breast meat yield. Since the growth of breast meat (pectoralis major) is more sensitive to DLM

Table 6 Effect of dietary energy and methionine source on carcass yield of broiler chicks at 6 weeks of age.

Items	Component (g/100 g of bodyweight)					
	Eviscerated carcass	Pectoralis minor	Pectoralis major	Drumstick	Wing	Abdominal fat
Energy source						
Corn	79.72^{a}	3.38	14.75^{a}	9.97	7.66^{a}	2.09
Cassava	78.72^{b}	3.30	13.99^{b}	9.83	7.52^{b}	2.25
Dietary methionine						
MD	77.67^{B}	3.04^{B}	12.45^{B}	9.72	7.44^{B}	2.54^{A}
DLM	79.97^{A}	3.43^{A}	15.47^{A}	10.09	7.65^{A}	1.97^{B}
LMA	80.01^{A}	3.54^{A}	15.21^{A}	9.90	7.66^{A}	1.99^{B}
Statistic						
SEM	1.77	0.27	0.99	0.55	0.26	0.38
ES	*	NS	*	NS	*	NS
MS	*	*	*	NS	*	*
ES×MS	NS	NS	NS	NS	NS	NS

^{A,B,a,b} Means within a column with different superscripts for each parameter differ significantly (*P*<0.05); SEM = standard error of the mean; * = *P*<0.05; NS = not significant (*P*>0.05).

supplementation than other edible meat components (Moran, 1994), it was not surprising that supplementation with DLM or LMA significantly improved breast meat yield.

In the current study, the growth performance (weight gain and FCR) of chicks fed LMA was not different from the performance of those fed DLM. Therefore, it was concluded that the bioefficacy of LMA relative to DLM for weight gain during the starter and grower period is approximately 88%. This finding in the current study agreed with the findings of Bunchasak and Keawarun (2006) who reported that the bioefficacy of LMA relative to DLM for weight gain was more than 80%.

CONCLUSION

The average bioefficacy of LMA relative to DLM was 88%. FCR and carcass yields of chicks fed the corn-soybean diets were better than those of chicks fed the cassava-soybean diets. The supplementation of the methionine-deficient diet with DLM or LMA significantly improved eviscerated carcass and breast meat yields. The chicks fed the corn-soybean diet had low abdominal fat. However, adding methionine could prevent the negative impact of amino acid imbalance and improve the energy utilization in a chick-fed diet based on cassava-soybean.

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