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Response of Broiler Chicks to Supplemental Inorganic Sulphate and Sulphite Compounds in a Tropical Environment

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Abstract

Key Words: Methionine, Sodium sulphate, Sodium sulphite supplementation, Broiler diets.

A feeding trial was conducted to determine the effectiveness of sulphate and sulphite compounds in sparing sulphur amino acid, methlonine, in broiler chicks raised in a tropical environment. A significant ($P < 0.05$) growth response was obtained by the addition of 0.30% DL-methionine to a corn-soybean basal diet, confirming that the diet was deficient in methionine. The best growth performance was obtained in the diet supplemented with 0.15% methionine plus 0.10% sodium sulphate (Na_2SO_4). The addition of sodium sulphite (Na_2SO_3), either singly or plus methionine, gave a significant ($P<0.05$) decrease in weight gain although feed efficiency was slightly improved. The weights of organs as a proportion of body weight varied significantly among dietary treatments. The weights of liver increased ($P<0.05$) in all supplemented diets with the exception of the diet containing 0.15% methionine plus 0.15% Na_2SO_4, while the weights of kidney and spleen decreased with the exception of the diet supplemented with 0.30% methionine. Enhanced levels of serum protein. and serum albumin ($P<0.05$) in diets supplemented with methionine and Na_2SO_4, indicated good nutritional status of birds consuming these feeds whereas enhanced levels of uric acid and creatinine in diets supplemented with Na_2SO_3 indicated poor feed quality. The hypothesis is advanced that there is either a dietary requirement for sulphate *per se* or that sulphate spares methionine through conversion to cystine.

1 Introduction

The sulphur amino acids are the most deficient or among the more deficient amino acids in many diets fed to poultry under intensive management systems in the tropical environment. This is because plant proteins from mainly soybean (*Glycine max*) and to a lesser extent groundnut (*Arachis hypogaea*), which are deficient in methionine and

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cystine, are the major protein sources used in formulating animal feeds in the tropics. The demand for these ingredients has increased tremendously in recent times due to high costs of imported feed additives and attention is now turning towards the exploitation of other novel plant proteins indigenous to Africa. In these plant proteins, methionine also represents the first limiting amino acid (OLOGHOBO, 1987) and in order to fully utilise the high production potential of broiler birds, this amino acid has to be supplemented.

Reports by Ross et al (1992), Harms (1972) and Hinton and Harms (1972), have indicated that sodium sulphate can be used to replace part of the methionine in broiler rations and, therefore, can reduce the cost of feeds. Similar observations were made by Almquist (1964), who further stated that sodium sulphate was about 40% as efficient as was sulphur amino acid in producing a growth response. More recently, a report by Harms (1992) showed that peak growth rate of broiler chicks was obtained when a corn-soybean basal diet (0.40% methionine and 0.39% cystine) was supplemented with 0.1% methionine and 0.1% sodium sulphate. From the data obtained in this study it appeared that the chicken either was unable to utilise the sulphur amino acid to supply its inorganic sulphur needs or was very inefficient in carrying out the conversion. These data suggested, therefore, that it would be more economical to meet the chickens requirement for inorganic sulphur directly rather than with supplemental methionine.

Based on these observations and coupled with the fact that all the works so far reported were carried out under temperate conditions with no heat stress, the present investigation was designed to determine the response of broiler chicks raised in a tropical environment to sulphate and sulphite compounds in a diet containing natural foodstuff.

2 Materials and Methods

Two hundred and forty day-old unsexed broiler chicks of the Hubbard strain were used in this study. They were divided, using a completely randomized design, into eight dietary treatment groups such that there were three replicates of 10 chicks per replicate for each diet. The chicks were raised in electrically heated starting batteries with screen floors.

Eight experimental rations were formulated. All chicks received the basal ration (Table 1) with or without supplemental methionine, anhydrous sodium sulphate and/or sodium sulphite, according the experimental plan. The basal diet was designed to be low both in sulphur amino acids and in added sulphur compounds. The supplements were added at the expense of corn. The control group received the unsupplemented basal diet, while three of the treatment groups were fed the basal diet supplemented with 0.30% of either DL-methionine, reagent grade Na_2SO_4 or Na_2SO_3. Two other treatment groups were fed the basal diet supplemented with 0.15% methionine and in addition 0.15% or 0.10% Na_2SO_4, while the remaining two groups received a similar treatment as above except that Na_2SO_3 replaced Na_2SO_4. All diets were calculated to provide 23.00% crude protein and 2900 Kcal/g metabolisable energy.

Table 1: Composition of basal diet (23% crude protein; 2900 KCal/kg ME).

Ingredients	%
Maize, ground	55.5
Soyabean meal (50% protein)	28.0
Blood meal	5.5
Brewers dried grain	6.5
Oyster shell	1.0
Bone meal	0.5
Salt, iodised	2.5
Premix[2]	0.5

Food and water were supplied *ad libitum* and uniform light was provided 24 hours daily. The chicks were weighed individually at the beginning of the experiment, and twice weekly thereafter until they were four weeks old when the experiment was terminated.

At 28 days metabolic studies were carried Out for five extra days at the end of which blood samples were taken by cardiac puncture from six birds (two per replicate) chosen at random from each group. Blood was collected in ice-cooled centrifuge tubes and the sera obtained were used to estimate total proteins (WOOTTON, 1964), serum albumin (DOUMAS and BIGGS, 1972); creatinine (SLOT, 1965), serum urea (FAWCETT and SCOT 1966) and uric acid (SEARCY, 1969). The birds were then fasted overnight and killed by cervical dislocation. Each bird was wet plucked, head and feet removed and the internal organs were dissected out and weighed.

Proximate analyses of diets and excreta were carried out according to the procedures of the AOAC (1975). All data were subjected to analysis of variance and the means separated by Duncan's multiple range tests (STEEL and TORRIE 1960).

3 Results and Discussion

The results of the performance of broiler chickens fed corn-soybean diets supplemented with methionine or inorganic sulphur compounds are given in Table 2. Feed intakes were significantly ($P<0.05$) different between dietary treatments, with a marked trend to increase with methionine and sodium sulphate (Na_2SO_4) supplements of the

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[2] The micro-ingredient mix supplied the following per kg of finished feed: 1.72mg retinol, 0.025mg cholecalciferol, 22.72mg tocopherol, 3 memenadione, 2.5mg riboflavin, 0.05mg cobalamine, 5mg pantothenic acid, 12.5mg niacin, 175mg choline, 0.5mg folic acid, 2.8mg Mg, 0.5mg Fe, 50mg Cu, 25mg Zn, 625mg Co.

diets. The results obtained in the study confirms that the corn-soybean basal diet was low in methionine as well as inorganic sulphate, since significant ($P<0.05$) increases in body weights were obtained from supplementations with 0.30% methionine and 0.15% methionine plus 0.10% Na $_2SO_4$. However, the best growth performance was obtained in the diet supplemented with 0.15% methionine plus 0.10% Na $_2SO_4$ which further confirms that supplementation with both methionine and Na_2SD_4 gives better growth than supplementation with either of them (MARTIN et al, 1966; SOARE et al, 1974).

Table 2: Performance characteristics of experimental Birds

Diet No.	1	2	3	4	5	6	7	8
Supplements								
Methionine	-	0.15	0.15	0.15	0.15	0.30	-	-
Na2SO4	-	0.10	-	0.15	-	-	0.30	-
Na2SO3	-	-	0.10	-	0.15	-	-	0.30
Performance Characteristics								
Feed Intake (g)	51.15^{h2}	57.23^{a}	41.34^{c}	51.91^{h}	43.52^{c}	51.34^{b}	51.08^{h}	46.58^{c}
Weight Gain (g)	13.41^{h}	15.23^{a}	11.42^{c}	14.00^{b}	11.89^{c}	14.26^{ab}	13.63^{h}	12.40^{c}
Feed: gain	3.81	3.76	3.62	3.71	3.6^{h}	3.60	3.75	3.76
Protein Efficiency Ratio	1.03	1.05	1.21	1.05	1.10	1.07	1.05	1.03
Dry Matter digestibility (%)	68.24c	75.15^{a}	71.42^{h}	73.75^{a}	70.24^{h}	71.62^{h}	71.58^{h}	68.45^{c}
Nitrogen retention (%)	53.77^{h}	75.18^{a}	68.13^{hc}	66.62^{c}	58.50^{a}	70.29^{h}	63.33^{d}	65.73^{cd}

1 Mean weight gains of 30 chicks per treatment

2 Means in the same row with different superscripts are significantly different at the $P<0.05$ level.

The worst performances in terms of feed intake and weight gain were obtained in the diets containing Na_2SO_3, either supplemented alone or with methionine. The result here not only agrees with that of Martin (1972), that is, sulphite had no effect on growth, but also shows that Na_2SO_3 could depress growth, although this may be due to the low feed intake by birds on diets supplemented with sulphite. The comparable result in feed efficiency (feed: gain ratio) obtained in this work, contradicts the findings of Almquist (1964) and Soares et al (1974) but corroborates the results of Ross and Harms (1970). The disparity may be explained in terms of the longer period of study used by Ross and Harms (1970), (eight weeks) and in this study (five weeks) as against three weeks used by Soares et al (1974). Older birds are likely to digest feed more thoroughly because their gizzard is more developed and thus can utilise it more efficiently than younger birds. The superior ($P<0.05$) dry matter digestibility and nitrogen retention values by birds on diets supplemented with methionine and methionine plus Na_2SO_4 are consistent with the result of the growth pattern.

Table 3: Relative Organ Weights (g/100g Body Weight) *

Treatments	Relative Organ Weights					
	Liver	Kidney	Spleen	Heart	Gizzard	Proven-ticulus
Basal	3.86^{b}	1.17^{b}	0.56^{b}	0.82	5.73^{bc}	1.40
Basal + 0.15% methionine * 0.10% Na_2SO_4	4.79^{a}	0.85^{ab}	0.38^{bc}	1.17	6.49^{b}	1.07
Basal + 0.15% methionine * 0.10% Na_2SO_3	4.17^{b}	1.11^{b}	0.42^{b}	1.09	7.92^{a}	1.25
Basal + 0.15% methionine + 0.15% Na_2SO_4	3.70^{b}	0.52^{c}	0.29^{c}	0.81	4.67^{c}	0.64
Basal + 0.15% methionine + 0.15% Na_2SO_3	4.17^{b}	0.79^{a}	0.40^{b}	1.16	8.42^{a}	1.56
Basal + 0.30% methionine	4.32^{ab}	0.71^{a}	0.71^{a}	1.08	7.05^{ab}	1.03
Basal + 0.30% Na_2SO_4	$4{\cdot}38^{a}$	$0{\cdot}59^{c}$	$0{\cdot}41^{b}$	0.91	$8{\cdot}16^{a}$	1.25
Basal + 0.30% Na_2SO_3	4.06^{ab}	0.68^{a}	0.22^{c}	0.83	6.50^{b}	1.16

* Mean values in the same row with different superscripts are significantly different at the $P<0.05$ level.

The weights of organs as a percentage of body weight are shown in Table 3. There were significant differences ($P<0.05$) in the weights of the liver, kidney, spleen and proventiculus among dietary treatments. With the exception of the diet supplemented with 0.15% methionine. plus 0.15% Na_2SO_4, all the supplemented diets gave significant ($P<0.05$) increases in the weights of the liver compared to the unsupplemented basal diet. The weights of the kidney and spleen, on the other hand, decreased with methionine and inorganic sulphur supplements except in birds fed basal diet supplemented with 0.30% methionine, for which there was a slight increase in the weight of the spleen relative to the other dietary treatments. The spleen is one of the hematopoietic organs of the body (OSCAR, 1970) and it may be that methionine supplementation favours blood formation more than any of the two salts. This, if true, may explain the higher ($P<0.05$) weight obtained in the dietary treatment supplemented with only methionine. This hypothesis should not however be carried far in the absence of further evidence as nutritional influences on haematology are complex (FARINU, 1984).

The concentrations of serum metabolites are summarised in Table 4. Total protein, albumin and creatinine were significantly ($P<0.05$) influenced but uric acid was not. Total serum protein and albumin levels in methionine - and methionine plus Na_2SO_3 - supplemented diets were higher ($P<0.05$) than in other diets. Enhanced levels of both proteins are indicative of good nutritional status (MAYERS, 1990). While the weight gain of birds fed basal diet plus methionine is in line with this result, birds on basal diet supplemented with metbionine plus Na_2SO_3 recorded poor growth, and therefore the high levels of proteins in the serum appear unaccounted for. Higher levels of uric acid and creatinine obtained in birds on supplemental Na_2SO_3 are either indicative of kidney malfunctioning (GELSON and ACKERMAN, 1975) or poor feed quality (MAYERS, 1990). In the absence of any kidney abnormality, it may be inferred that the diet with 0.15% methionine plus 0.15% Na_2SO_3 was of poorer quality than other diets. However, contrary to this observation, there was a consistent response to the supplementation of Na_2SO_4, in agreement with previous studies (ROSS and HARM, 1970, FARINU, 1984). This lends further support to the hypothesis that there is either a dietary requirement for sulphate or that sulphate spares methionine through conversion to cystine.

Table 4: Serum inetabolites of experimental birds (mg/100ml).*

Treatments	**Serum metabolites**			
	Total protein	**Albiumin**	**Uric acid**	**Creatinine**
Basal	3.45[b]	2.15[b]	1.69	1.68[ab]
Basal + 0.15% methionine + 0.10% Na_2SO_4	3.66[ab]	2.20b	1.72	1.94[a]
Basal + 0.15% methionine + 0.10% Na_2S0_3	4.22[a]	2.61[a]	1.31	1.56[b]
Basal + 0.15% methionine + 0.15% Na_2SO_4	3.75[ab]	2.42[b]	1.73	1.89[a]
Basal + 0.15% methionine + 0.15% Na_2SO_3	3.15[b]	2.07[b]	2.04	2.71[a]
Basal + 0.30% methionine	4.21[a]	2.67[a]	1.28	1.57[b]
Basal + 0.30% Na_2SO_4	3.53[b]	2.27[b]	1.70	1.61[b]
Basal + 0.30% Na_2SO_3	3.15[b]	2.07[b]	1.69	1.64[b]

*Mean values within the same row with different superscripts are significantly different at ($P<0.05$).

In view of the fact that inorganic sulphate is involved in the metabolism of many tissues and systems as well as in important detoxification mechanisms, it seems reasonable to provide an adequate quantity of inorganic sulphur in the diet. On the basis of the results from this study, it would appear advisable to use the sulphate forms of trace minerals in the diet of poultry birds to provide an adequate level of sulphate.

4 Zusammenfassung

Die Auswirkung von Sulphat- und Sulphitzusätzen in Broilerfutter für in den Tropen gehaltene Broiler

Schlagwörter: Methione, Sodium Sulphat- und Sodium Sulphitzussätze, Broilerfutter

In dem Grundfutter das in intensiven Haltungssystemen eingesetzt wird, fehlen oft Sulphuraminosäuren und um das Produktionspotential der Broiler nutzen zu können, sollten Aminosäuren zugesetzt werden. In Fütterungsversuchen wurde festgestellt, daß

ein signifikantes Wachstum beim Zusatz von 0,30% DL-Methionin erreicht wurde. Die höchste Zuwachsrate wurde beim Zusatz von 0,15% DL- Methionin und 0,10% Sodium Sulphat im Futter erreicht. Dies stärkt die Hypothese, daß entweder Sulphat per se notwendig ist oder Sulphat Methionine durch Umwandlung in Cystine ersetzt.

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