Neth. J. agric. Sci. 28 (1980) 147-155

Broiler growth response from practical low-protein diets supplemented with urea and diammonium hydrogen phosphate

A. R. El Boushy

Department of Poultry Husbandry, Agricultural University, 6700 AH Wageningen, the Netherlands

Accepted: 20 March 1980

Key words: urea, diammonium hydrogen phosphate, broilers, starter, finisher, feed conversion

Summary

An experiment involving was conducted on 480 one-day old chicks (Hybro) kept in cages, sexed 50 % males and females. The chicks were divided into six groups and given one of the following practical diets ad libitum, as a starter for the first 4 weeks: (A) 23.5 % crude protein, rich in essential amino acids; (B) 20.6 % crude protein, containing essential amino acids to meet requirements; (C) B + 1 % urea; (D) B + 0.5 % urea; (E) B + 2.2 % diammonium hydrogen phosphate — $(NH_4)_2HPO_4$, DAP — and (F) B + 1 % DAP. The finisher diets were: (A) 20 % crude protein; (B) 18 % crude protein with essential amino acids to meet requirements; (C) B + 0.7 % urea; (D) B + 0.35 % urea; (E) B + 1.5 % DAP, (F) B + 0.75 % DAP.

Adding 1 % urea and 2.2 % DAP to the starter diets depressed growth and feed conversion significantly, whereas 0.5 % urea and 1.1 % DAP had no significant effects on growth and feed conversion, compared with control A.

Adding 0.7 and 0.35 % urea to the finisher diets depressed growth and feed conversion compared with diet A. Whereas the diet containing 0.75 % DAP showed better results than that containing 1.5 % DAP, there was no significant effect on growth, compared with group A.

At 7 weeks of age, low concentrations of urea and DAP did not produce results that differed significantly from control B as far as feed conversion was concerned, but they were not comparable to control diet A.

Introduction

The use of non-protein nitrogen (NPN) to meet part of the protein needs of animals other than ruminants has been of great interest in the last few years. It was thought that only ruminants could utilize urea, ammonium salts and other forms of NPN, because they are able to convert the nitrogen to protein by means of rumen bacteria.

The utilization of various non-protein sources by broilers has been the subject of much research in the last few years. The extent to which utilization occurs depends on the type of diet to which the NPN source is added.

Sullivan & Bird (1956) indicated that the chick can use urea and diammonium citrate (DAC) when fed low-protein diets, provided adequate essential amino acids are given.

Featherston et al. (1962) demonstrated significantly that chicks fed semi-purified diets use urea and diammonium citrate (DAC) to synthesize dispensable amino acids.

Blair et al. (1972), Lee & Blair (1972) and Baker & Molitoris (1974) showed that the growth of broiler chicks was increased when various non-protein nitrogen sources were added to diets that are based on crystalline amino acids.

Koci & Grom (1972) reported that when urea provided up to 20 % of the protein in broiler diets, positive responses only occurred when animal protein (fish meal) was included to provide adequate supplies of the most limiting amino acids (in their case lysine and methionine).

In contrast McNab et al. (1972) reported that diets supplemented with ammonium salts, significantly depressed the growth of broilers. Balloun & Kazemi (1975) and Trakulchang & Balloun (1975) pointed out that adding DAC to low-protein diets, caused significant growth retardation and poorer feed conversion.

Kagan & Balloun (1976) found that urea as a protein substitute does not improve the value of conventional broiler diets and that although it is absorbed into the blood stream, it is not assimilated into body proteins.

In recent studies, Lee (1977) observed that diets low in non-essential amino acids did not support higher growth rates when supplemented with urea.

In view of the above-mentioned inconsistent results, it was thought desirable to investigate the effects of some sources of non-protein nitrogen on broiler performance when fed conventional diets.

Material and methods

480 One-day old chicks (Hybro), sexed 50 % males and females, were obtained from a commercial flock and kept in cages, ten birds in each cage. The birds were confined in battery cages with raised wire floors with perforated rubber carpets. Feed and water were supplied ad libitum. The house was warmed by means of thermostatically controlled air heaters; artificial light was provided 24 hours daily.

The chicks were devided into six experimental groups each repeated four times.

Diets were calculated by means of linear programming in order to meet the essential amino acid requirements at minimum protein levels.

The dietary ingredients were analysed for crude protein and amino acids (Table 1) before the rations were calculated by the computer.

The basal diets were formulated to contain high and low protein levels for starter and finisher periods respectively. The other groups of diets were supplied

Table 1. Percentage of amino acids in dietary ingredients.*

	Ingredient				
	yellow maize	soyabean oilmeal	herring meal	meat meal	whey powder
Crude protein (N × 6.25)	8.44	46.56	76.38	60.44	12.56
Tryptophan	0.073	0.64	0.84	0.49	0.20
Lysine	0.25	2.82	5.66	3.24	0.76
Histidine	0.26	1.19	2.38	1.34	0.20
Arginine	0.42	3.35	4.09	3.77	0.30
Threonine	0.34	2.03	3.45	2.19	0.84
Serine	0.46	2.61	3.29	2.68	0.64
Glutamic acid	1.65	8.69	9.81	6.95	2.14
Proline	0.74	2.32	2.89	4.17	0.73
Glycine	0.34	1.98	4.68	6.95	0.25
Alanine	0.65	2.01	4.59	4.21	0.55
Cystine	0.21	0.73	0.74	0.69	0.27
Valine	0.45	2.40	4.11	3.01	0.70
Methionine	0.21	0.71	2.07	0.78	0.19
Isoleucine	0.33	2.33	3.45	1.72	0.75
Leucine	1.06	3.54	5.51	4.02	1.14
Tyrosine	0.39	1.74	2.41	1.51	0.35
Phenylalanine	0.43	2.31	2.86	2.29	0.37

* Amino acids were estimated with the Jeol 6-AH autoanalyzer. Amino acids were determined by the method of Spackman et al. (1958) and Slump (1969).

with several levels of urea and diammonium hydrogen phosphate (DAP) (Tables 2 and 3).

Individual body weight and feed consumption were measured weekly; growth and feed conversion (feed/gain) were calculated; mortality was recorded daily.

All data were analysed factorally for variance and, when applicable, treatment means were separated by Duncan's multiple range test (1965).

Results and discussion

The body weight and growth of the broilers are shown in Table 4. There were significant effects of urea and diammonium hydrogen phosphate (DAP) supplementations at 4 weeks of age. Urea diet C and DAP diet E depressed growth significantly in comparison with control diets A and B. Lower concentrations of urea (diet D), showed better results of growth than high concentrations (diet C), though not significantly. Diet F showed significantly higher growth than diet E. Diet F did not differ significantly form the control diet A and B.

Our results support the finding of Blair & Warning (1969) who noticed that compared with a control diet growth was depressed with high levels of DAP and

Table 2. Starter diets from 0-4 weeks.

Compostion	High protein A	Low protein B	Supplemented C	D	E	F
Yellow maize	63.8	70.1	*	*	*	*
Soyabean oilmeal (44.9 %)	13.3	10.0	*	*	*	*
Meat meal (58.2 %)	5.0	1.7	*	*	*	*
Herring meal (72.9 %)	12.0	12.0	*	*	*	*
Whey powder (12. 4 %)	1.0	1.0	*	*	*	*
Salt iodized	0.4	0.4	*	*	*	*
Destructed animal fat (98.0 %)	1.8	1.1	*	*	*	*
Vitamin trace elements suppl.[1]	1.0	1.0	*	*	*	*
Limestone (35.0 %)	0.9	1.2	*	*	*	*
Calcium hydrogen phosphate dihydrate[2] (23.3 % Ca, 19 % P)	0.4	1.0	*	*	*	*
Urea (N 46.65 %)	–	–	1.0	0.5	–	–
Diammonium hydrogen phosphate (N 21.21 %)	–	–	–	–	2.2	1.1
Percentage calculated						
ME (MJ/kg)	13.12	13.20	*	*	*	*
Crude protein (N × 6.25)	23.5	20.6	23.5	22.05	23.5	22.03
Amino acid content						
Tryptophan	0.26	0.23	*	*	*	*
Lysine	1.38	1.20	*	*	*	*
Histidine	0.68	0.61	*	*	*	*
Arginine	1.40	1.18	*	*	*	*
Threonine	1.02	0.90	*	*	*	*
Serine	1.18	1.03	*	*	*	*
Glutamic acid	3.76	3.34	*	*	*	*
Proline	1.34	1.18	*	*	*	*
Glycine	1.39	1.12	*	*	*	*
Alanine	1.45	1.29	*	*	*	*
Cystine	0.36	0.33	*	*	*	*
Valine	1.26	1.11	*	*	*	*
Methionine	0.52	0.48	*	*	*	*
Isoleucine	1.03	0.91	*	*	*	*
Leucine	2.02	1.83	*	*	*	*
Tyrosine	0.85	0.76	*	*	*	*
Phenylalanine	1.04	0.92	*	*	*	*

[1] Vitamin and trace elements supplement contains per kilogram: 1 200 000 I.U. vitamin A; 200 000 I.U. vitamin D_3; 500 I.U. vitamin E; 0.15 g vitamin K_3; 0.1 g vitamin B_1; 0.5 g vitamin B_2; 0.1 g vitamin B_6; 3 g nicotenic acid; 0.75 g D. pantothenic acid; 1.5 mg vitamin B_{12}; 50 mg folic acid; 35 g choline chloride; 10 mg Se; 2 g Fe; 7 g Mn; 1 g Cu; 3 g Zn; 0.1 g I; 0. 3 g Co.

[2] Trivial name: dicalcium phosphate ($CaHPO_4 \cdot 2H_2O$).

* As in diet B.

Table 3. Finisher diets from 4-7 weeks.

Composition	High protein A	Low protein B	Supplemented C	D	E	F
Yellow maize	71.3	73.8	*	*	*	*
Soyabean oilmeal (44.9 %)	10.0	10.4	*	*	*	*
Meat meal (58.2 %)	1.2	2.4	*	*	*	*
Herring meal (72. 9 %)	11.3	7.0	*	*	*	*
Whey powder (12. 4 %)	1.0	1.0	*	*	*	*
Destructed animal fat (98.0 %)	1.0	1.2	*	*	*	*
Salt iodized	0.4	0.4	*	*	*	*
Vitamin trace elements suppl.[1]	1.0	1.0	*	*	*	*
Limestone (35 %)	1.3	1.2	*	*	*	*
Calcium hydrogen phosphate dihydrate[2] (23.3 % Ca, 19 % P)	1.1	1.2	*	*	*	*
Urea (N 46.65 %)	–	–	0.7	0.35	–	–
Diammonium hydrogen phosphate (N 21.21 %)	–	–	–	–	1.5	0.75
Percentage calculated						
ME (MJ/kg))	13.20	13.19	*	*	*	*
Crude protein (N × 6.25)	20	18	20	19	20	19
Amino acid content						
Tryptophan	0.22	0.19	*	*	*	*
Lysine	1.15	0.96	*	*	*	*
Histidine	0.59	0.52	*	*	*	*
Arginine	1.14	1.04	*	*	*	*
Threonine	0.87	0.77	*	*	*	*
Serine	1.00	0.91	*	*	*	*
Glutamic acid	3.26	3.00	*	*	*	*
Proline	1.14	1.10	*	*	*	*
Glycine	1.06	0.96	*	*	*	*
Alanine	1.24	1.12	*	*	*	*
Cystine	0.32	0.30	*	*	*	*
Valine	1.07	0.95	*	*	*	*
Methionine	0.47	0.40	*	*	*	*
Isoleucine	0.89	0.78	*	*	*	*
Leucine	1.79	1.64	*	*	*	*
Tyrosine	0.75	0.68	*	*	*	*
Phenylalanine	0.89	0.82	*	*	*	*

[1] Similar to the starter diets (Table 2).

[2] Trivial name: dicalcium phosphate ($CaHPO_4 \cdot 2H_2O$).

* As in diet B.

was normal with low levels of DAP. McNab et al. (1972) came to the same conclusions using different non-protein nitrogen sources.

No significant differences were apparent in body weight and growth at 7 weeks

Table 4. The effect of supplemented urea and diammonium hydrogen phosphate to diets on the broiler performance.[1]

Diets		Body weight (g)		Growth (g)	
starter (0-4 weeks)	finisher (4-7 weeks)	4 weeks	7 weeks	4 weeks	7 weeks
A: 23.5 % CP[2]	A: 20 % CP	717.3^{b} ± 4.15 (100)	1584.7 ± 12.7 (100)	677.1^{b} ± 7.0 (100)	1544.4 ± 12.4 (100)
B: 20.6 % CP	B: 18 % CP	720.5^{b} ± 9.7 (100)	1592.3 ± 14.1 (100)	679.5^{b} ± 9.8 (100)	1551.3 ± 14.3 (100)
C: as B + 1.0 % urea	C: as B + 0.7 % urea	685.5^{a} ± 9.4 (96)	1553.1 ± 18.2 (98)	645.8^{a} ± 8.3 (95)	1512.8 ± 18.0 (98)
D: as B + 0.5 % urea	D: as B + 0.35 % urea	697.8^{ab} ± 9.5 (97)	1553.9 ± 19.7 (98)	657.5^{ab} ± 9.3 (97)	1513.6 ± 19.5 (98)
E: as B + 2.2 % DAP[2]	E: as B + 1.5 % DAP	676.2^{a} ± 14.2 (94)	1543.7 ± 23.3 (97)	635.7^{a} ± 14.3 (94)	1503.2 ± 23.3 (97)
F: as B + 1.1 % DAP	F: as B + 0.75 % DAP	721.5^{b} ± 7.1 (101)	1585.8 ± 17.2 (100)	681.1^{b} ± 6.9 (101)	1545.4 ± 16.8 (100)

Diets		Feed consumption (g/bird)		Feed conversion	
starter (0-4 weeks)	finisher (4-7 weeks)	4 weeks	7 weeks	4 weeks	7 weeks
A: 23.5 % CP	A: 20 % CP	1175.3 ± 3.8 (100)	3177.0^{a} ± 35.0 (100)	1.738^{ab} ± 0.007 (100)	2.063^{a} ± 0.012 (100)
B: 20.6 % CP	B: 18 % CP	1171.5 ± 14.5 (100)	3284.9^{bc} ± 19.4 (103)	1.727^{a} ± 0.014 (99)	2.130^{b} ± 0.009 (103)
C: as B + 1.0 % urea	C: as B + 0.7 % urea	1148.3 ± 9.4 (98)	3256.2^{abc} ± 17.6 (102)	1.785^{cd} ± 0.020 (103)	2.159^{bc} ± 0.025 (105)
D: as B + 0.5 % urea	D: as B + 0.35 % urea	1152.8 ± 18.1 (98)	3216.6^{ab} ± 31.6 (101)	1.756^{abc} ± 0.015 (101)	2.130^{b} ± 0.008 (103)
E: as B + 2.2 % DAP	E: as B + 1.5 % DAP	1145.4 ± 23.7 (97)	3273.1^{abc} ± 45.1 (103)	1.804^{d} ± 0.008 (104)	2.184^{c} ± 0.004 (106)
F: as B + 1.1 % DAP	F: as B + 0.75 % DAP	1207.6 ± 10.1 (103)	3331.4^{c} ± 28.0 (105)	1.776^{bcd} ± 0.022 (102)	2.160^{bc} ± 0.009 (105)

[1] Means with different subscripts vertically are significantly different ($P < 0.05$) with Duncan's Multiple Range Test. After the means the standard error and (in parenthesis) the percentage are given.

[2] CP = crude protein; DAP = diammonium hydrogen phosphate.

Table 5. Various calculations of crude protein, true protein and amino acids in the several diets in relation to total consumption and consumption/kg growth.

	0-4 weeks						0-7 weeks					
	A	B	C	D	E	F	A	B	C	D	E	F
Calculated crude protein (%)	23.5	20.6	23.5	22.05	23.5	22.03	20	18	20	19	20	19
True protein (%)	23.5	20.6	20.6	20.6	20.6	20.6	20	18	18	18	18	18
Crude protein (g consumed/bird)	276	241	276	254	276	266	676	624	697	646	702	670
Crude protein (g consumed/kg growth)	408	355	427	386	434	382	438	402	461	427	467	435
True protein (g consumed/bird)	276	241	241	241	241	241	676	624	620	613	624	623
True protein (g consumed/kg growth)	408	355	373	367	379	354	438	402	410	405	415	403
Methionine (g consumed/bird)	6.11	5.62	5.52	5.53	5.50	5.80	15.52	14.12	13.95	13.79	14.01	14.30
Methionine (g consumed/kg growth)	9.03	8.27	8.55	8.41	8.65	8.52	10.05	9.10	9.22	9.11	9.32	9.25
Methionine + cystine (g consumed/bird)	10.34	9.49	9.31	9.37	9.28	9.78	26.16	24.37	24.06	23.82	24.18	24.65
Methionine + cystine (g consumed/kg growth)	15.25	13.97	14.42	14.25	14.60	14.36	16.94	15.71	15.90	15.74	16.09	15.95
Lysine (g consumed/bird)	16.21	14.06	13.80	13.83	13.74	14.49	39.23	34.47	34.02	33.64	34.17	34.88
Lysine (g consumed/kg growth)	23.94	20.69	21.37	21.04	21.62	21.27	25.40	22.22	22.49	22.23	22.73	22.57

of age between the several dietary treatments, although there were some noticeable depressions with diets C, D (urea) and E (DAP). Blair & Warning (1969) came to similar conclusions with birds at 6 weeks of age.

Feed consumption was not significantly affected at 4 weeks of age (Table 4), but there were some depressions with urea diets C, D and DAP diet E, while diet F showed higher consumption. This higher consumption of group F was accompanied by a higher consumption of methionine and lysine (Table 5) which may have caused the better body weight and growth of this group.

Feed consumption at 7 weeks of age showed some significant differences among the several groups. Group B, with a low protein content, showed significantly higher feed consumption in comparison with groups A, with a high protein content. It seems that the birds with the low protein diet tried to compensate for it by higher feed consumption, however, the essential amino acids were adequate (Table 3). Groups E and F (DAP) showed a higher feed consumption in comparison with groups C and D (urea). It seems that urea inhibits feed consumption due to the palatability effects or due to the higher level of urea in blood plasma, which may affect the appetite of the birds.

At 4 weeks of age, feed conversion was (not significantly) lower in group B (low protein) than in group A (high protein), but this picture changed at 7 weeks of age due to the higher feed consumption in group B (Table 4). At both 4 and 7 weeks, feed conversion was depressed significantly by diets C and E, with high concentrations of urea and DAP respectively. Although diets D and F contained low concentrations of urea and DAP respectively, they did not change feed conversion compared with low-protein diet B. Diets C, D (urea), E and F (DAP) showed a significant depression compared with diet A. The only difference was that diet D, low urea, produced similar results to low-protein diet B. Thus, increasing the levels of urea and DAP clearly depressed feed conversion.

Our results support the findings of Trakulchang & Balloun (1975) who reported that adding diammonium citrate (DAC) in high levels of 2.85 % of 5.70 % to low protein basal diets depressed feed efficiency significantly and those of Kagan & Balloun (1976), who concluded that urea supplementation to a low protein diet did not improve feed efficiency in the starter and finisher periods of broilers. More recently, Nathanael et al. (1976) concluded that adding DAC to a low-protein diet did not improve feed conversion at 4 weeks of age.

Our results proved that neither urea nor DAP in high concentrations were used for protein synthesis by broilers fed on conventional diets low protein, even when the diets were adequate in essential amino acids.

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