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Protein, essential amino acids and glycine requirements of the growing gosling (*Anser cireneus*)*

BY ZAFRIRA NITSAN

Division of Poultry Science, Agricultural Research Organization, The Volcani Center, Rehovot, Israel

AND A. DVORIN

Akko Goose Breeding and Research Farm, PO Box 35, Akko, Israel

AND I. NIR

Department of Animal Science, The Hebrew University of Jerusalem, Faculty of Agriculture, Rehovot, Israel

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1. The dietary requirements for protein and amino acids of the growing gosling (0–7 weeks) were calculated according to body composition, maintenance needs and the absorption rate of amino acids from feeds.

2. The diets were formulated by least-cost linear programming, using the calculated requirements for amino acids, with or without minimal glycine + serine requirements. The diets formulated without minimal requirements of glycine + serine were supplemented with various amounts of glycine, and fed to growing goslings.

3. The calculated requirements for protein and essential amino acids were lower than those suggested for growing broilers and turkeys. The requirements (g/MJ metabolizable energy) at 0–2, 2–4 and 4–7 weeks of age respectively, were: lysine 0·88, 0·48, 0·43; methionine + cystine 0·48, 0·38, 0·29; protein 14·5, 9·3, 7·6.

4. The goslings did not respond to glycine supplementation of the diet.

The dietary requirements for protein and amino acids of the growing gosling (*Anser cireneus*) have not been studied systematically and hence reliable nutritive recommendations are not available. Estimated lysine values only may be derived from the (US) National Research Council (1977) recommendations.

Rational prediction equations of essential amino acid requirements of growing animals are based on the needs for maintenance and tissue growth and on the efficiency of absorption. This approach has been used for growing chicks (Hurwitz *et al.* 1978).

In a previous study, growth and composition (protein, amino acids, fat and ash) of carcass, skin and feathers were determined periodically from hatching to 7 weeks of age (Nitsan *et al.* 1981 *a*). Average amino acid absorption was 0·86 (Nitsan *et al.* 1981 *b*), similar to that reported for chicks (Lepkovsky *et al.* 1965; Hurwitz *et al.* 1972).

The purpose of the present study was to calculate the requirements for amino acids in the growing gosling according to the rational approach, using body composition and absorption-rate values and to validate these findings by feeding these rations to growing goslings.

The relative weight of skin and feathers is very high in the gosling (Nitsan *et al.* 1981 *a*). These tissues contain high levels of glycine and serine. Glycine can be readily synthesized by birds, but during periods of rapid growth the rate of synthesis may not satisfy the needs for

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Table 1. *Calculated protein and amino acids requirements (g/kg body-weight gain (BG) and g/MJ metabolizable energy (ME) intake) of goslings during the periods 0–2, 2–4 and 4–7 weeks of age**

(Values given in parentheses are expressed as g/Mcal ME)

Age (weeks)...	0–2		2–4		4–7	
	g/kg BG	g/MJ ME	g/kg BG	g/MJ ME	g/kg BG	g/MJ ME
Protein	226·9	14·53	285·0	9·32	295·9	7·65
Amino acids						
Threonine	9·3	0·59 (2·5)	11·8	0·38 (1·6)	12·3	0·31 (1·3)
Glycine (Gly)	19·0	1·19 (5·0)	22·6	0·74 (3·1)	23·8	0·59 (2·5)
Serine (Ser)	11·2	0·72 (3·0)	16·6	0·55 (2·3)	16·0	0·43 (1·8)
Gly+Ser	30·2	1·91 (8·0)	29·1	1·29 (5·4)	39·8	1·03 (4·3)
Methionine (Met)	3·7	0·24 (1·0)	3·9	0·12 (0·5)	4·4	0·12 (0·5)
Cystine (Cys)	3·7	0·24 (1·0)	7·8	0·26 (1·1)	6·5	0·17 (0·7)
Met+Cys	7·4	0·48 (2·0)	11·7	0·38 (1·6)	10·9	0·29 (1·2)
Valine	9·9	0·62 (2·6)	13·2	0·43 (1·8)	13·2	0·33 (1·4)
Isoleucine	7·9	0·50 (2·1)	10·1	0·33 (1·4)	10·4	0·26 (1·1)
Leucine	16·0	1·00 (4·2)	19·8	0·64 (2·7)	20·7	0·52 (2·2)
Tyrosine	7·3	0·48 (2·0)	10·6	0·33 (1·4)	10·4	0·26 (1·1)
Phenylalanine	9·0	0·57 (2·4)	11·4	0·36 (1·5)	11·9	0·31 (1·3)
Histidine	5·4	0·33 (1·4)	5·9	0·19 (0·8)	6·7	0·19 (0·8)
Lysine	13·8	0·88 (3·7)	14·7	0·48 (2·0)	16·6	0·43 (1·8)
Arginine	15·3	0·95 (4·0)	18·7	0·62 (2·6)	19·7	0·50 (2·1)

* Calculated according to a previous experiment in which average BG values were 660, 1010 and 1780 g for the periods 0–2, 2–4 and 4–7 weeks respectively, with an ME intake of 10·4, 31·0 and 69·0 MJ during the respective periods.

tissue growth and for nitrogen excretion, as glycine is one of the precursors of uric acid Scott *et al.* 1976).

In the present investigation, the response of growing goslings to increasing amounts of glycine in the diet was also studied.

EXPERIMENTAL

Calculation of amino acid requirements and diets

Amino acid requirements (AAR; g) in various growth periods were calculated according to the following equation:

$$\text{AAR} = [\underbrace{(T \times 1{\cdot}6 \times A_c \times W)}_{\text{maintenance}} + \underbrace{(C \times P_c \times A_c)}_{\text{carcass}} + \underbrace{(F \times P_f \times A_f)}_{\text{feathers}} + \underbrace{(S \times P_s \times A_s)}_{\text{skin}}] \div 0{\cdot}86$$

where T is the time-period (d), 1·6 is the protein need for maintenance (g/kg body-weight) according to Leveille & Fisher (1958) for roosters, A_c is the amino acid concentration in carcass protein (g/16 g N), W is the average weight (g) during the time-period T, C is the carcass increment (g) during the time-period T, P_c is the protein concentration in carcass (g protein/g carcass), F is the feather increment (g) during the time-period T, P_f is the protein concentration in feathers (g protein/g feathers), A_f is the amino acid concentration in feather protein (g/16 g N), S is the skin increment (g) during the time-period T, P_s is the protein concentration in skin (g protein/g skin); A_s is the amino acid concentration in skin protein (g/16 g N), 0·86 is the mean amino acid absorption rate from feeds. In the previously-mentioned equation, we assumed that the proportion of amino acids needed for maintenance is similar to that of the carcass composition described by Nitsan *et al.* (1981 *a*).

Table 2. *Composition of the experimental diets as computed by least-cost linear programming*

Age (weeks)...	0–2		2–4		4–7	
Diet no....	1	1a	2	2a	3	3a
Glycine+serine requirement...	–	+	–	+	–	+
Ingredients (g/kg)						
Sorghum†	200	200	206	459	486	491
Maize	431	378	562	300	300	300
Soya-bean meal (44%)	300	295	127	93	113	109
Soya-bean oil	20	28	10	10	10	10
Poultry byproduct meal	—	50	—	47	—	8
Feather meal	—	20	—	7	—	—
Wheat bran	—	—	16	51	12	44
Wheat middlings	—	—	40	—	40	—
Fish meal	16	—	—	—	—	—
Dicalcium phosphate	12	10	15	11	16	15
Calcium carbonate	14	13	17	16	17	17
Sodium chloride	3	3	3	3	3	3
DL-Methionine	—	—	0·21	—	—	—
L-Lysine	1·1	—	—	—	—	—
Vitamin and microelements mix*	3	3	3	3	3	3
Metabolizable energy (ME; MJ/kg)	12·5	12·5	12·5	12·5	12·5	12·5
Protein (g/kg)	188	230	134	150	127	130
Glycine+serine (g/kg)	18	24	13	16	12	13
Methionine (g/kg)	3	3	2	2	2	2
Methionine+cystine (g/kg)	6	7	5	5	4	4
Lysine (g/kg)	11	11	6	6	5·4	5·4
Arginine (g/kg)	12	15	8	9	8	8
Calcium (g/kg)	9	9	10	10	10	10
Total phosphorus (g/kg)	6	6	6	6	6	6

–, Formulated without minimal requirements of glycine+serine; +, formulated to supply a minimum of 1·91, 1·29 and 1·03 g glycine+serine/MJ ME (see calculated requirements, Table 1).

* As described by Nir *et al.* (1974).

† Sorghum white grain (milo), 13·9 kJ ME and 100 g protein per kg.

The calculated AAR of the growing gosling during different time-periods are presented in Table 1. The least-cost formula was computed by linear programming, the energy required being 12·5 MJ metabolizable energy (ME)/kg, and the amino acids composition of the feed ingredients as suggested by the (US) National Research Council (1977). The diets obtained from the computed requirements for protein and amino acids, including glycine+serine (Table 1), are presented in Table 2 (diets 1a, 2a, 3a). Since the status of glycine+serine as partially-essential amino acids is debatable (Scott *et al.* 1976), another set of diets was computed for each age period without minimal requirements for glycine+serine (diets 1, 2, 3).

Feeding experiments

Expt *1*. Unsexed goslings (1-d-old) were divided into nine groups of twenty goslings each according to body-weight. The goslings were kept in rooms and were brooded up to 2 weeks with electrically-heated brooders. Three groups were allocated to each treatment. All goslings were fed *ad lib.* The goslings received, from 0 to 2 weeks of age, diet 1 (Table 2) which was supplemented with 0, 3·0 or 6·0 g glycine/kg. In order to avoid a possible after-treatment effect, the goslings used from 2 to 4 weeks were selected from a flock given a commercial diet (220 g protein/kg, 12 MJ ME/kg) and divided into nine groups (three

Table 3. *Expt 1. Body-weight gain, food intake and food utilization in goslings as affected by dietary glycine levels*

(All diets contained 12·5 MJ ME/kg. Protein concentration was 188 g/kg from 0–2 weeks and 134 g/kg from 2–4 weeks)

Age 0–2 weeks					Age 2–4 weeks				
Glycine supplementation (g/kg)	Dietary glycine + serine (g/kg)	Body-wt gain (g)	Food intake (g)	Body-wt gain:food intake	Glycine supplementation (g/kg)	Dietary glycine + serine (g/kg)	Body-wt gain (g)	Food intake (g)	Body-wt gain:food intake
0	18·0	598	748	0·799	0	13·0	929	2141[a]	0·434[b]
3·0	21·0	572	745	0·768	1·5	14·5	970	1945[b]	0·499[a]
6·0	24·0	566	709	0·798	3·0	16·0	908	1976[b]	0·458[b]
SEM (6 df)		12·2	15·2	0·020			21·2	32·0	0·008

[a, b], Mean values with unlike superscript letters were significantly different ($P < 0·05$).
ME, metabolizable energy.

groups/treatment) of twenty goslings each, according to body-weight. During this period, diet 2 (Table 2) was used. It was supplemented with 0, 1·5 or 3·0 g glycine/kg.

Expt 2. Five groups of ten male goslings each were kept in electrically-heated individual cages and were brooded up to 2 weeks of age. From 0 to 2 weeks of age, diet 1, supplemented with 0, 1·5, 3·0 or 6·0 g glycine/kg, and diet 1a (Table 2) were used. From 2 to 4 weeks, diet 2 supplemented with 0, 0·75, 1·5 or 3·0 g glycine/kg, and diet 2a were used. In this experiment, the cumulative effect of glycine supplementation was studied. Therefore, the same goslings were used throughout the experimental periods.

Expt 3. Geese (4 weeks old) given a commercial diet (220 g protein/kg, 12 MJ ME/kg), were divided into four groups of seventy-five birds each, according to body-weight. Diet 3 (Table 2) was compared with a commercial diet containing 10·7 MJ ME/kg and 135 g protein/kg (protein:energy according to the (US) National Research Council (1977), from 6 weeks onwards). The commercial diet contained 12·6 g protein/MJ while the experimental one only 10·2 g protein/MJ. Both diets were pelleted. This commercial diet has been used on the Akko Experiment Farm for the past 3 years. Each diet was fed to two groups from 4 to 7 weeks of age.

*Expt 3a.*This experiment was similar to Expt 3. It was carried out with three replicates of forty-five geese each per treatment (a total of 270 geese).

In all experiments, food intake and body-weight were determined weekly. The values were subjected to analysis of variance as described by Cochran & Cox (1957), with separation of means by Duncan's (1955) multiple-range test.

RESULTS

Calculated amino acid requirements and diets

The calculated protein and essential amino acid requirements of the growing gosling are shown in Table 1. The requirements for sulphur amino acids were calculated to be lower (by about 30%) than those suggested for broiler chicks ((US) National Research Council, 1977) from hatching to 7 weeks of age. Lysine and arginine requirements were calculated to be lower than those of broiler chicks from 2 weeks of age onwards. The calculated requirements for glycine + serine were considerably higher for goslings than those suggested for broiler chicks.

Table 4. *Expt 2. Body-weight gain, food intake and food utilization in goslings as affected by dietary protein and glycine levels*
(All diets contained 12·5 MJ metabolizable energy/kg)

Age 0–2 weeks						Age 2–4 weeks					
Glycine supplementation (g/kg)	Dietary glycine + serine (g/kg)	Protein level (g/kg)	Body-wt gain (g)	Food intake (g)	Body-wt gain:food intake	Glycine supplementation (g/kg)	Dietary glycine + serine (g/kg)	Protein level (g/kg)	Body-wt gain (g)	Food intake (g)	Body-wt gain:food intake
0	18·0	188	715	971[a]	0·740[b]	0	13·0	134	1230[bc]	2990[ab]	0·412
1·5	19·5	188	689	907[ab]	0·761[b]	0·75	13·7	134	1337[a]	3193[a]	0·422
3·0	21·0	188	653	879[ab]	0·743[b]	1·5	14·5	134	1283[ab]	3069[ab]	0·420
6·0	24·0	188	651	837[ab]	0·784[b]	3·0	16·0	134	1277[abc]	3097[ab]	0·413
0	24·0	230	681	801[b]	0·862[a]	0	16·0	150	1178[c]	2880[b]	0·410
SEM (45 df)			29·1	42·7	0·022				35·1	94·1	0·011

[a, b, c] Values with unlike superscript letters were significantly different ($P < 0.05$).

Table 5. *Expts 3 and 3a. Body-weight gain, food intake and food utilization in goslings given the experimental diet (protein: energy 10·2) or a commercial diet (protein: energy 12·4) from 4 to 7 weeks of age*

Expt no.	Dietary protein (g/kg)	Dietary energy (MJ ME/kg)	Body-wt gain (g)	Food intake (g)	Body-wt gain:food intake	Protein intake (g)	Body-wt gain:protein intake	Energy intake (MJ ME)	Body-wt gain:ME intake
3	127*	12·5	1721	5625	0·306	714	2·41	70·4	24·4
	135†	10·9	1553	5600	0·277	756	2·05	61·0	25·5
SEM (2 df)			48·6	12·7	0·008	12·0	0·104	2·69	0·35
3a	127*	12·5	1730[a]	5627	0·308	715	2·42[a]	70·4[a]	24·6
	135†	10·9	1535[b]	5582	0·277	754	2·04[b]	60·9[b]	25·2
SEM (4 df)			44·9	90·9	0·055	14·8	0·090	2·37	0·37

[a, b] Values with unlike superscript letters were significantly different ($P < 0.05$).
ME, metabolizable energy.
* Diet 3, Table 2.
† Commercial diet, see p. 458.

When minimal requirements for glycine + serine were imposed to a least-cost formulation by linear programming, they were supplied by an excess of protein of animal origin (mainly feathers and poultry byproducts meal, Table 2). This excess was substantial in the 0–2 week period and diminished subsequently.

Feeding experiments

Expt 1 (*Table 3*). Glycine supplementation had no statistically-significant effect on body-weight, decreased food intake slightly (statistically significant for 2–4 weeks of age) and improved food utilization.

Expt 2 (*Table 4*). Up to 2 weeks of age glycine supplementation caused a slight reduction in food intake and body-weight gain, which was negatively related to the glycine concentration in the diet (r −0·96 and −0·89 respectively). Later this slight depression was compensated for, and at the end of the experimental period (4 weeks) no significant differences between the groups were found in food intake and body-weight. Up to 2 weeks of age, food utilization was significantly improved by the high-protein diet, but this effect was not maintained.

Expt 3 (*Table 5*). The performance of the goslings given the experimental diet (diet 3, Table 2) was superior to that of those given the commercial diet. Body-weight gain was higher, while food consumption was similar. Food and protein utilization was improved accordingly, while energy utilization was similar in both groups. Statistical analysis of food intake or utilization values could not be carried out because the geese were fed on a group basis (two groups/treatment).

Expt 3a. This experiment confirmed the results of Expt 3. The experimental diet improved body-weight gain and protein utilization ($P < 0.05$).

DISCUSSION

The responses of goslings given diets formulated according to body composition, with or without imposing minimal glycine requirements, were similar. This was found whether glycine supplements were given at hatching or at 2 weeks of age. High protein concentrations did not have a favourable effect. It seems that the gosling is able to synthesize enough glycine at an early age, when feather growth is maximal. Between 2 and 4 weeks of age the relative weight of the feathers increases 2·5–3-fold (Nitsan *et al.* 1981 *a*). The slight depression in appetite caused by the addition of glycine to the diet could be due to a specific depressing effect of glycine. It has been postulated that several amino acids, especially glycine, glutamic, aspartic and γ-amino butyric acids, are neurotransmitters in the central nervous system (Curtis & Crawford, 1969).

The over-all protein retention by the goslings, according to body composition values (Nitsan *et al.* 1981 *a*), was between 50 and 60%. This retention is close to that reported for chicks (Scott *et al.* 1976). It can be concluded that the protein and amino acid requirements of the growing gosling are considerably lower than those suggested by the (US) National Research Council (1977). When essential amino acid concentration is adequate, a protein: ME value of 15 g/MJ from 0–2 weeks, and of 9 g/MJ thereafter, seems to be adequate. It seems that the formal approach may be useful in the calculation of essential amino acid requirements for the growing gosling as was reported for chicks (Hurwitz *et al.* 1978).

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