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Metabolic Faecal Nitrogen and Endogenous Urinary Nitrogen Excretions by Growing Chicks

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FOUR experiments were conducted using 415 young chicks being fed semipurified diets for the purpose of estimating the metabolic faecal nitrogen and endogenous urinary nitrogen excretions by applying the Ekman Chemical method. The direct method of feeding the chicks a nitrogen free and nitrogen low diets gave values of 1.78 g metabolic faecal nitrogen per kg food intake (D.M.B.) and 0.151 g endogenous urinary nitrogen per $W_{kg}^{0.75}$ per day. The indirect method by feeding the chicks graded protein levels and extrapolating to zero nitrogen intake, gave values of 1.42 g metabolic faecal nitrogen per kg food intake (D.M.B.) and 0.023 endogenous urinary nitrogen per $W_{kg}^{0.75}$ per day. This very low estimate was mainly due to the curvilinear relationship between the unrinary nitrogen excretions and true absorbed nitrogen.

The conventional method of determining the endogenous body losses is by feeding the animal or bird a nitrogen - free or a low nitrogen diet, adequate in all other respects. The constant level of nitrogen excretions. in the faeces and urine represent respectively the metabolic faecal nitrogen and endogenous urinary nitrogen excretions ; in applying these values to animal fed protein-diet it is assumed that these excretions are constant per unit of food consumed and of metabolic body size respectively (Mitchell, 1924 Burroughs *et al.*,1970 and Mitchell, 1955).

It is generally agreed that the endogenous nitrogen losses via faeces and must be allowed for if true digestibility and biological value of food proteins are to be determined. This work was undertaken to determine such fractions using two classical methods with two crosses of chicks.

Material and Methods

Four experiments were carried out with7-day old chicks. Male crossbred (Rhode Island Red X white Leghorn) chicks were used in exp. 1, 3 and 4 but female crossbred (Rhode Island x Light Sussex) were anailable in experimen 2; all chicks were purchased from a commercial hatchery. The day-old chicks fed a commercial diet (18 percent crude protein) for one week after which time they were allocated in the experimental cages and fed semi-purified diets as described by Abdel Salam, (1964). The number of the chicks, sex and breed for each experiment are tabulated as follows :

Experiment No.	Number of chicks	Sex	Breed
1	120	Male	R.I.R. × W.L.
2	120	Female	R.I.R. × L.S.
3	95	Male	R.I.R. × W.L.
4	80	Male	R.I.R. × W.L.

Two methods were followed to determine the metabolic faecal nitrogen and endogenous urinary nitrogen excretion by applying the Ekman method (Ekman *et al.* 1949), the two methods are as follows :

(1) The direct method by feeding the chicks a nitrogen free or a nitrogen low diet.

(2) The indirect method by feeding the experimental chicks an increasing dietary crude protein and extrapolating back to zero protein intake to calculate the metabolic faecal nitrogen and the endogenous urinary nitrogen.

For the direct method, in experiments 1 and 2 two groups of chicks of 15 chicks each were fed the nitrogen-free and nitrogen low diets for 9 days at 3-day interval collecting excreta ; in experiments 3 and 4 facilities permitted the triplicate of this treatment of 5 chicks each.

For the indirect method, in experiments 1 and 2, seven groups of chicks of 15 each were fed graded levels of crude protein, in experiments 3 and 4 treatments were in triplicate where four graded levels only of crude protein were fed to the chicks. The average initial liveweight of chicks in various treatments was not exceeding 5 g than any of the other treamtents in same experiment.

The composition of the basal experimental semi-purified diet is shown in Table 1 together with various protein sources and levels for each experiment.

Results

Metabolic faecal nitrogen excretion

Table 2 shows the data for metabolic faecal nitrogen excreted by chicks fed nitrogen-free and nitrogen low diets. The low-nitrogen diets contained approximately from 3 up to 7 percent crude protein in the diet. Dried egg-white was the main protein source in diets of experiments 1,2 and 3 while the sole source was decorticated cottonseed meal (containg 45% crude protein) in experiment 4. The metabolic faecal nitrogen excretions are expressed per kg food consumed (D.M.B) and on metabolic body size when body weight is raised to 0.75 power. The over all mean of the metabolic faecal nitrogen is found to be 1.78 g per kg-food intake or 0.086 per $W_{kg}^{0.75}$ per day.

The data for total faecal nitrogen excretion together with the dietary crude protein level (D.M.B.) for experiments 1,2,3 and 4 are shown in Table 3.

TMBLE 1. The composition of experimental diets including the different protein sources and the basal ingredients.

Treatment	Protein source and levels for different diets						
	1	2	3	4	5	6	7
Dried egg white :							
Exp. 1.	(3)* 3.3**	(6) 5.4	(9) 8.6	(12) 11.6	(15) 13.7	(20) 19.6	(30) 28.2
Exp. 2.	(6) 6.6	(9) 9.4	(12) 13.5	(15) 16.5	(20) 20.0	(30) 26.8	(35) 31.3
Exp. 3.	(6) 7.6	(12) 11.3	(18) 17.0	(24) 22.2	— —	— —	— —
Dec. cotton seed meal:							
Exp. 4.	(11.8) 5.6	(23.5) 10.7	(35.3) 18.4	(47.1) 23.4	— —	— —	— —
Basal ingredients % of diet							
Corn oil				18.00			
Cellulose				5.00			
Vitamin mixture* . .				0.08			
Choline Chloride . .				0.20			
Mineral mixture** .				5.37			
Sodium bicarbonate				1.00			
Antacid absorbant .				1.00			
Corn starch : glucose mixture 4 : 1 . . .				up to100			

* Figures in parentheses indicate pecentage protein source in the diet.

** Figures indicate percentage crude protein (N × 6.25) on D.M.B.

+ and ++ vitamine and mineral mixtures are described by Abdel Salam, (1964).

Fig. 1 and 2 show the amount of faecal nitrogen (g) excreted per kg food intake (D.M.B.) (y) and per $W_{kg}^{0.75}$ per day (y) respectively, both plotted against percentage dietary crude protein (D.M.B.) (×).

A linear relationship was found between both parameters in the two figures. The regression equations (were fitted by the method of least squares and are:

in Fig. 1

exp. 1 $y = 0.0243 \times + 1.32$

exp. 2 $y = 0.1444 \times + 1.50$

exp. 3 $y = 0.0272 + \times 1.50$

exp. 4 $y = 0.2169 \times + 1.36$

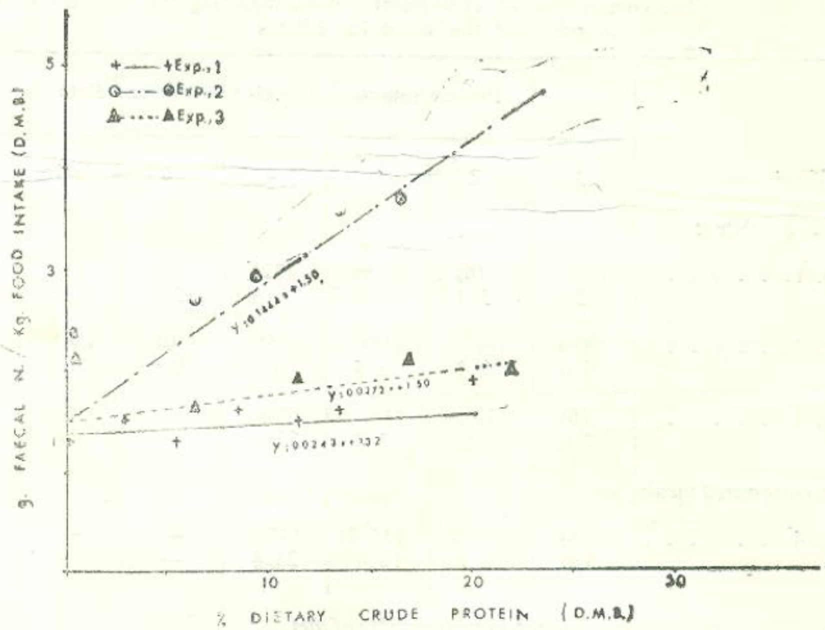

Fig. 1. Relationship between faecal nitrogen (g) per kg food intake (D.M.B.) (Y) and% dietary crude protein (D.M.B.) (X)

in Fig.2.

exp. 1	y = 0.041 × + 0.062
exp. 2	y = 0.122 × + 0.098
exp. 3	y = 0.003 × + 0.064
exp. 4	y = 0.013 × + 0.040

Endogenous urinary nitrogen excretions

Table 4 shows the daily endogenous urinary nitrogen excretions by chicks being fed a nitrogen-free and a nitrogen-low diet. The overall mean is 0.151g per $W_{kg}^{0.75}$

The total urinary nitrogen excretions and true absorbed nitrogen data for chicks fed increasing levels of dietary crude protein are shown in Table 6.

Fig. 3 shows the relationship between true absorbed nitroegn (×) and urinary nitrogen (y), both variates being expressed in g per $W_{kg}^{0.75}$ per day. It may be seen in that figure that at very low levels from 6.5 g absorbed nitrogen per $W_{kg}^{0.75}$ the urinary nitroegn excretions were fairly constant.

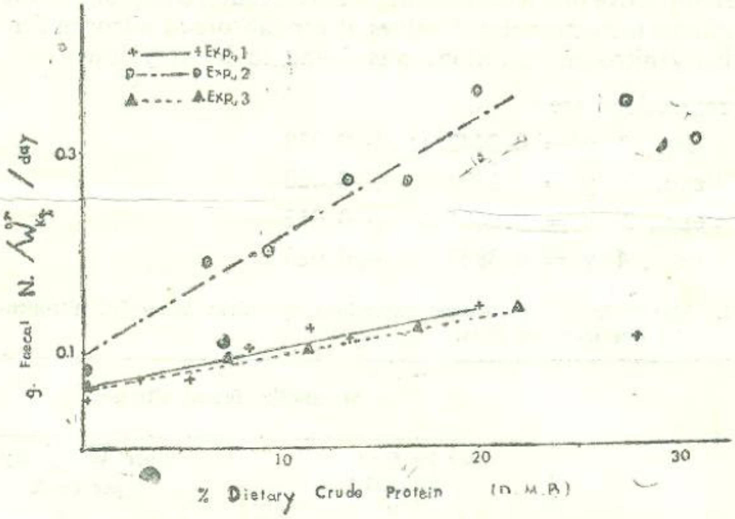

Fig. 2. Relationship between faecal nitrogen (g) per $W_{kg}^{0.75}$ day (Y) and % dietary crude protein (D.M.B.) (X)

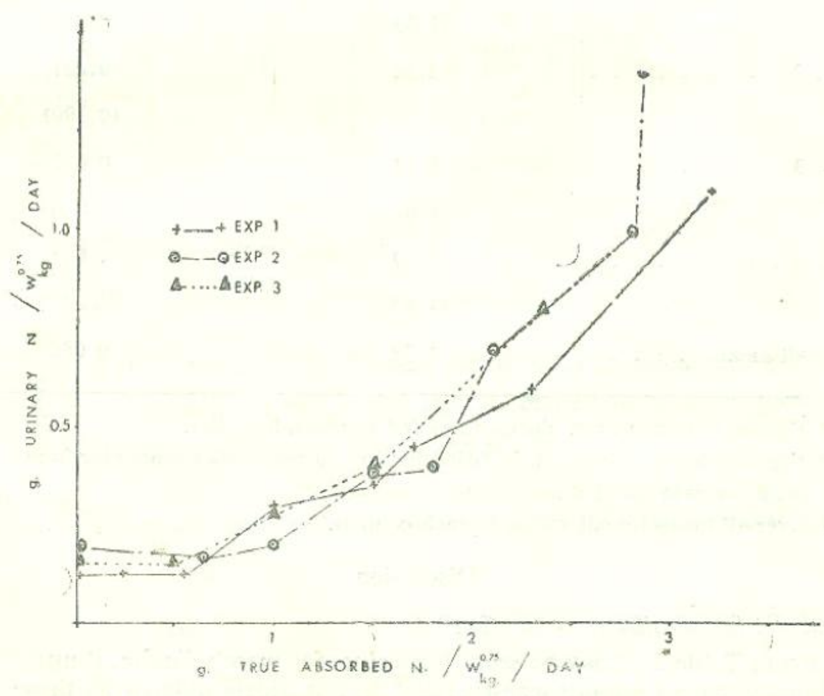

Fig. 3. Relationship between true absorbed nitrogen (X) and urinary N (Y) both variates bieng expressed in g per $W_{kg}^{0.75}$ / day

When the data above that level were fitted in regression equations by the metho d of least squares the extrapolated values at zero absorbed nitrogen for the minimum urinary nitrogen excretions was found to be very low.

The regressions are

Exp., 1 $y = 0.2442 \times + 0.038$
exp., 2 $y = 0.2124 \times + 0.020$
exp., 3 $y = 0.2685 \times + 0.012$
Exp., 4 $y = 0.3887 \times + 0.023$

TABLE 2. Metabolic faecal nitrogen excretions by chicks being fed nitrogen-free and low nitrogen diets.

	Metabolic faecal nitrogen	
	per kg food (D.M.B.) g	per $W_{kg}^{.075}$/day per chick g
Exp. 1	1.29*	0.053
	(1.53)**	(0.071)
	(1.33)	(0.072)
Exp. 2	2.38	0.081
	(2.72)	(0.190)
Exp. 3	3.13	0.061
	(1.61)	0.090)
Exp. 4	1.29	0.043
	(1.62)	(0.112)
Over-all meant	1.78	0.086

* Figures obtained from chicks being fed nitrogen-free diet.

** Figures obtained from chicks being fed low nitrogen, diet containing from 3 to 7% crude protein (D.M.B).

+ Over-all mean for all values in each column.

Discussion

Metabolic faecal nitrogen excretion

From Table 2 it may be seen that values for metabolic faecal nitrogen excretion by chicks fed nitrogen-free diet do not widely differ from those obtained by feeding nitrogen low diet up to approximately 7 percent dietary crude protein with an over all mean of 1.78 g per kg dry matter intake. Suggesting that egg white protein up to 7 percent and decorticated cotton-seed meal protein (containg 45% crude protein) were highly digestible that did not increase the faecal nitreogen excretions than in case of feeding the nitrogen-free diet. Mitchell (1924) determined the metabolic faecal nitrogen excretions by rats being fed 3% whole-egg protien. Vanlandingham *et al.* (1945) with growing chicks and Ariyoshi (1967) with adult bird determined the metabolic faecal nitrogen and endogenous urinary nitrogen by feeding the birds low egg-protein diet up to 3%.

TABLE 3. **Total faecal nitrogen excretions by chicks being fed increasing levels of dietary crude protein.**

Dietary crude protein (N × 6.25) D.M.B. %	Total faecal nitrogen excretions	
	per kg food g	per $W_{kg}^{0.75}$ / day g
Experiment 1		
3.3	1.53	0.071
5.4	1.33	0.072
8.6	1.64	0.120
11.6	1.49	0.116
13.7	1.56	0.114
19.6	1.89	0.138
28.2	1.66	0.112
Experiment 2		
6.6	2.72	0.190
9.4	2.88	0.200
13.5	3.59	0.273
16.5	3.70	0.273
20.0	4.84	0.359
26.8	4.93	0.349
31.3	5.03	0.308
Experiment 3		
7.6	1.61	0.090
11.3	1.91	0.103
17.0	2.08	0.116
22.2	1.99	0.139
xperiment 4		
5.6	1.62	0.112
10.7	2.14	0.175
18.4	3.38	0.308
23.4	4.47	0.372

TABLE 4. **Daily endogenous urinary nitrogen excretions by chicks being fed nitrogen-free and nitrogen-low diets.**

	N. in diet (D.M.B.) %	Endogenous urinary nitrogen excretion $g/W_{kg}^{0.75}$
Experiment 1		
	0.02	0.116
	0.52	0.123
	0.86	0.124
Experiment 2		
	0.13	0.169
	1.05	0.164
Experiment 3		
	0.06	0.152
	0.90	0.152
Experiment 4		
	0.06	0.123
	0.89	0.236
Mean	0.50	0.151

The indirect method for determining the metabolic faecal nitrogen excretions by chicks fed increasing dietary crude protein levels gave vaules of 1.32, 1.50, 1.50 and 1.36 g per kg food dry matter intake when dietary crude protein is zero for experimetnts 1, 2, 3, and 4 respectively with an average value of 1.42. The latter value has to be compared with 1.78 g obtained by the direct feeding method. Erikson (1955) who similarly employed the Ekman method for separating total faecal nitrogen from total excreta, a value of 1.45 g can be calculated from his extrapolated data. A value of 0.92 g per kg food may be also calculated from the data of Aryoshi (1957) by feeding, surgically modified birds to provide an artificial anus, a nitrogen free diet. St. John *et al.* (1932) Macdonald and Bose (1944) and Ekman *et al.* (1949) found values of 2.9, 3.1 and 2.4 g per kg food respectively with chickens fed nitrogen free diet. It may be seen that values for metabolic faecal nitrogen per kg food for chicks obtained in the present work by the direct feeding method and indirectly by extrapolation lie in the range of that for chickens by other workers using other methods. It is worthnoting that other investigators (Bell *et al.* 1950; Armstrong and Mitchell, 1955 workig with pigs and Mitchell and Bert, (1954, with rats) who demonstrated the linear relationship between dietary crude protein and faecal nitrogen to food ratio over a range up to 10 to 20 percent crude protein have reported similar values for metabolic faecal nitrogen excretions in the present study (Table 5).

TABLE 5. **Endogenous urinary nitrogen excretions for chicks and other animal species (expressed per $W_{kg}^{0.75}$ per day)**

References and species of animals	Direct feeding method value g	Extrapolated value g
Poultry		
chicks		
Present study		
Experiment 1	0.116	0.038
Experiment 2	0.169	0.020
Experiment 3	0.152	0.012
Experiment 4	0.123	0.023
Adult birds		
Macdonald and Bose (1944)	0.162	
Ekman *et al.* (1949)	0.141	
Ariyoshi (1957)	0.118	
Other species		
Growing pigs		
Armstrong & Mitchell (1955)	0.106	0.133
Rats		
Mitchell (1955)		0.120
Metta & Mitchell (1956)	0.116	
Dogs		
Allison *et al.* (1947)		0.070

The effect of body size on metabolic faecal nitrogen excretions has been demonstrated by Schneider (1935) with rats and pigs, and also reported by Lofgreen and Kleiber (1953) with calves. The average daily metabolic faecal nitrogen excretion by the direct method was found to be 0.086 g per $W_{kg}^{0.75}$. The extrapolated value was averaged to 0.088 per $W_{kg}^{0.75}$ which is in good agreement with the direct feeding method.

The present data suggest that the metabolic faecal nitrogen excretion by chicks can be determined with reasonable accuracy by the direct feeding method instead of the extrapolated data which is laborious.

TABLE 6.—Daily total urinary nitrogen excretions and true absorbed nitrogen data for chicks fed increasing levels of dietary crude protein

Nitrogen in diet (D.M.B.) %	Metabolic body size of chicks $W_{kg}^{0.75}$	Urinary nitrogen g / $W_{kg}^{0.75}$	True absorbed nitrogen g / $W_{kg}^{0.75}$
Experiment 1			
0.52	0.173	0.123	0.249
0.86	0.186	0.124	0.547
1.37	0.217	0.277	1.032
1.85	0.229	0.349	1.524
2.20	0.241	0.451	1.722
3.13	0.260	0.610	2.260
4.51	0.283	1.094	3.138
Experiment 2			
1.05	0.165	0.164	0.649
1.50	0.180	0.222	0.989
2.16	0.199	0.392	1.508
2.64	0.210	0.403	1.790
3.21	0.226	0.639	2.133
4.30	0.229	0.961	2.800
5.00	0.219	1.404	2.840
Experiment 3			
0.90	0.199	0.152	0.493
1.81	0.218	0.272	1.020
2.73	0.236	0.419	1.480
3.41	0.303	0.820	2.348
Experiment 4			
0.89	0.186	0.236	0.596
1.72	0.215	0.496	1.326
2.94	0.252	0.970	2.465
3.75	0.256	1.252	2.855

Endogenous urinary nitrogen excretion

It may be seen from Table 4 that reasonable agreement was found between values of endogenous urinary nitrogen excretions by chicks fed a nitrogen-free diet and a low-nitrogen diet with an over all mean of 0.151 g per $W_{kg}^{0.75}$. When extrapolated values for endcgenosus urinary introgen of 0.038, 0.020, 0.012 and 0.023 per $W_{kg}^{0.75}$ per day for experiments 1,2, 3, and 4 respectively were compared with those obtained by the direct feeding method they were found to be very low. A value of 0.162 g per $W_{kg}^{0.75}$ may be calculated from data reported by Macdonald and Bose (1944) with chickens fed nitrogen free-diet. Also a value of 0.141 g per $W_{kg}^{0.75}$ may be obtaind from data presented by Ekman *et al.* (1949) with adult birds fed nitrogen free diet. Ariyoshi (1957) reported a value of 0.118 g per $W_{kg}^{0.75}$ with adult birds surgically modified to provide an artificial anus and fed a nitrogen free diet. More recently Tasaki and Okumura (1964) reported a value of 0.234 ± 0.034 g per $W_{kg}^{0.75}$ when the adult birds were fed a nitrogen free diet while a value of 0.175 g per $W_{kg}^{0.75}$ when the endogenous urinary nitrogen was estimated from the regression equation calculated with the data of increasing increments of protein-containing diets. These workers attributed the excess of urinary nitrogen excretion by feeding a nitrogen free diet that the birds are forced to excrete excess ammonia to regulate the distrurbed acid-base balance, and not a product of the normal nitrogen metabolism. Even that the extrapolated values in the present work still lower than the normal excretion for the chicks in comparison with other species. Brody (1945) reported a value of 0.145 per $W_{kg}^{0.72}$ for most species which is in excellent agreement with an over mean value of 0.151 for endogenous urinary nitrogen excretion by chicks in Table 4. Moreover , when the endogenous urinary nitrogen : basal metabolism ratio was calculated for these chicks , assuming that the basal metabolism for young chicks is 104 kcal. per $W_{kg}^{0.75}$ as determined by Kleiber and Dougherty (1934) , the ratio was found to be 2.36 which fairly agreed with that of 2.004 ± 0.038 calculated by Mitchell (1962) for human and most animal species.

Such inherent error of estimating endogenous urinary nitrogen excretions by extrapolation was observed by Hoffman *et al.* (1948) with human beings. Njaa (1959) Forbes *et al.* (1958) with rats suggested that the endogenous urinary nitrogen excretions may be underestimated by extrapolation. Further investigations, however, are warranted to determine the minimum urinary nitrogen excretion by chickens using the extrapolated data obtained from feeding the birds increasing levels of dietary protein.

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آزوت الروث التمثيلى وآزوت التمثيل الداخلى البولى فى زرق الكتاكيت النامية

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أجرى أربع تجارب على ٤١٥ كتكوت حديثة الفقس وغذيت على علائق شبه نقية كيميائية لغرض تقـدير الآزوت التمثيلى الناتج من هدم الجسم فى البول والروث وذلك باستعمال طريقة « اكمان » الكيميائية لفصل ازوت البول عن آزوت الروث .

وأعطت الطريقة المباشرة ـ بتغذية الكتاكيت على عليقة خالية من الأزوت ـ ازوت تمثيلى فى الروث بمعدل ١و٧٨جرام لكل كيلو جرام غذاء (على اساس المـادة الجافة تماما) ، ١٥١ر٠ جرام أزوت تمثيلى فى البول يوميا لكل كيلوجرام وزن تمثيلى حى مرفوعا الى الاس ٧٥ر٠

أما الطريقة غير المباشرة ـ بتغذية مجاميع من الكتاكيت مستويات مختلفة من البروتين وحساب الازوت التمثيلى عندما يكون ازوت الغذاء يعادل صفر ـ فقد أعطت بالحساب ١ر٤٢ جرام أزوت تمثيلى فى الروث لكل كيلوجرام غـذاء (على اساس المادة الجافة تماما) ٠٢٣٠ر٠ جرام يومياً ازوت تمثيلى فى البول لكل كيلو جرام وزن تمثيلى حى مرفوعا للاس ٧٥ر٠ ويعزى التقدير الحسابى المنخفض الى وجود علاقة غير مستقيمة تماما بين الأزوت الممتص فى الجسم والازوت الناتج فى البول ٠