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Studies on the Retention of Sulphur in Sheep

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FOURTEEN balance trials were carried out on sheep to establish the possibilities of natural difficiency of S under normal feeding practices, routes of excretion per kg live-weight (LW) or per unit metabolic body size (UMBS) of this mineral were determined.

The tested foodstuffs consisted of four green forages, two dry roughages, three grains and five milling and factory by-products. Energy and protein requirements were calculated for each experimental, animal and the rations were sufficient to maintain nitrogen equilibrium during the trial periods. Decorticated cottonseed cake and 2*nd* cut clover were found to contain the highest amount of sulphur. The lowest contents of sulphur were in rice bran and maize grains.

Sulphur balance was positive in all the tested feedstuffs. The main route of sulphur excretion was found to be in the faeces. The addition of sulphur rich casein increased sulphur output in urine and resulted in a narrow urinary nitrogen to sulphur ratio.

Sulphur enters the animal body largely as a constituent of the amino-acids systine, cysteine and methionine and to a smaller extent as glycoproteins, sulphoproteins, and inorganic sulphates in the diet. The body utilizes these acids in synthesis of the S-containing regulators of its metabolism such as glutathione and insulin. Two vitamins, thiamine and biotin, contain S. Thiocyanate ions are also present in blood, as well as in the saliva and other secretions.

Starks and Rose (1938)and Tarver and Schmidt (1939) indicated that the sulphur of methionine could be used to synthesise cystine in the animal's body. In ruminants, at least, inorganic sources might supply some of the need for this element. Block *et al.* (1950-1951) found that radio active S^{35} was recovered in the protein fraction of goats milk and in cystine and methionine in the rumen contents. Starks *et al.* (1953) found that the addition of S caused a significant increase in the retention of nitrogen and sulphur and an increase in wool growth. Machlin and Pearson (1956) found that the addition of 0.5 % Na_2So_4 to a diet low in sulphur stimulated the growth of young

chicks. Palfij (1963)found that the lactating cows got a supplement of 30g/day Na_2So_4 had higher plasma level of protein containing sulphur and produced 8% more milk than the control.

Hashino *et al.* (1963) studied the effect of oral administration of excess of L-methionine and L-cystine on S excretion in rat ruine. The contents of various S compounds in urine of rats fed L-methionine and L-cystine were determined as well as the relation between their intake and N excretion. In both cases these amino acids supplied 1.08%of total fed N content. The same authors found that with the increase of methionine intake, total urinary S compounds increased ,but tctal N decreased. However, by increasing cystine intake, both total S and N in urine increased. When methionine was substituted for cystine, total S excretion increased, whereas total N content showed a a slight decrease.

Rending and Weir (1957) reported that alfalfa containing 0.155 % total sulphur resulted in a good rate of weight gain in ruminants.

Experimental and Methods

Fourteen balance trials were carried out on sheep to determine sulphur content and retention from common Egyptian feedstuffs.

Feeding

Energy requirements as starch value was calculated for each experimental animal as mentioned by Kleiber (1961).

Protein contents of the rations were enough to cover the maintenance requirements as 1.76 g digestible protein/unit metabolic body size (UMBS) as reported by the same author. When wheat straw was tested,it was supplemented ,with 40 g casein/day to cover the maintenance requirements of protein. When concentrates and green maize were tested, clover hay was used as a basal constituent of the rations to supply half of the daily maintenance requirements of starch value. Water was offered *ad-libitum* and daily water consumption was recorded.

Composite samples

A daily proportion from faeces, urine, water, and green fodder was taken to prepare the composite samples for the collection period. For faecal sampling, one-tenth of the daily fresh faeces was taken just after collection and dried at 60° for 24 hr. A sample of preliminary dried faeces was dried at105° for 3hr for dry determinations. For urine one twentieth of the daily urine excretion was stored in a well stoppered polyethylene bottle containing 5 ml of toluene to prevent mould growth and used for sulphur determination. Another sample of the daily urine was stored in a bottle containing sulphuric acid and was used for nitrogen determination.

Chemical analysis

The chemical analysis of feedstuffs and faecal material for moisture and N followed the ordinary conventional methods of AOAC (1955). Sulphur was determined colorimetrically in feedstuffs and faeces using Middleton method (1962), while it was determined gravimetrically in urine and water according to Denis (1910) method.

Results

Sulphur content in feedstuffs

The results indicate that in roughages the highest content was in clover hay and the lowest was in green maize as shown in Table 1. On dry matter basis the S contents was the highest in the *2nd* cut clover and the lowest in wheat straw.

With concentrates, the highest content was in decorticated cottonseed cake and the lowest in rice bran. The S content was nearly equal in both maize and rice bran. Horse beans and wheat bran contents of S were similar.

TABLE 1 Sulphur excretion and its ratio with nitrogen excretion in urine.

Feedstuffs	Total S excretion	Excreted S		Excretion percent		N:S ratio
		in urine	in faeces	in urine	in faeces	
	g	g	g	%	%	
Roughages						
1*st* cut clover . .	3.773	1.720	2.053	45.60	54.40	7.32
2*nd* cut clover . .	3.596	1.034	2.562	28.85	71.15	8.12
3*rd* cut clover . .	3.210	0.796	2.414	24.72	75.28	7.78
Green maize . . .	3.537	0.924	2.613	26.04	73.96	8.54
Clover hay . . .	2.723	0.922	1.801	33.86	66.14	9.50
Wheat straw . . .	2.573	1.271	1.302	49.43	50.67	4.68
Concentrates						
Maize grains . .	2.682	0.810	1.872	30.33	69.67	11.40
Barley grains . .	3.009	0.753	2.256	25.02	74.98	11.04
Horse beans . .	3.179	0.650	2.529	20.25	79.75	17.28
Wheat bran . . .	3.679	0.730	2.949	19.60	80.40	12.62
Rice bran	1.666	0.470	1.196	25.22	74.78	13.14
Dect. cotton S.C.	4.731	1.321	3.410	27.85	72.15	17.06
Dedect. cotton S.C.	3.166	0.876	2.290	27.48	72.52	15.10
Food mixture	3.792	1.244	2.548	32.75	67.25	13.21

Sulphur excretion

It is shown from Table 1 that the faeces are the major pathway of excretion. The amounts of S excretion in urine in case of feeding green roughages were higher than that when concentrates were fed.

The relation between sulphur and nitrogen excretion in urine

In all trials, except with wheat straw where casein was added, N:S ratio ranged between 7.32 and 17.28 but it was 4.68 in wheat straw.

Sulphur retention

Table 2 clarified that sulphur balance was positive in all the trials. Concerning S retention/kg liveweight (LW) or per unit metabolic body size (UMBS), the results indicated that the 3*rd* cut clover had the highest retention, (being 96 and 240 mg, while horse beans had the lowest values, being 28 and 70 mg S. The values of retained S with the other feedstuffs were within the former two limits.

The correlation between N and S retained/kg LW or UMBS was only + 0.2473.

TABLE 2. **Daily retention of sulphur / kg LW or / UMBS.**

Feedstuffs	Intake	Retention	Retention	Retention kg LW	Retention UMBS
	g	g	%	mg	mg
Green roughages					
1 *st* cut clover	5.579	1.806	32.37	30	84
2 *nd* cut clover	6.557	2.961	45.12	79	186
3 *rd* cut clover	6.999	3.788	54.12	96	240
Green maize**	5.746	2.210	38.50	42	114
Dry roughages					
Clover hay	4.520	1.805	39.84	46	115
Wheat straw	3.462	0.888	25.64	57	137
Grains					
Maize	4.510	1.829	40.40	35	94
Barley	4.556	1.546	33.90	30	81
Beans	4.296	1.063	24.86	28	70
*By-products***					
Wheat bran	5.300	1.620	30.72	43	106
Rice bran	3.437	1.570	45.67	46	116
Dec. Cottonseed cake	7.300	2.790	37.08	54	144
Undec. ;, ,,	5.897	2.790	37.08	54	114
Feed mixture	6.504	2.711	41.66	50	136

* Supplemented with 40 g casein / animal / day.

**Half of the energy requirement was covered from clover hay.

Discussion

The narrow N:S ratio excreted in urine, when wheat straw was supplemented with casein, was due to the high S and low urinary N. That might be the result of two factors :

1. Casein and methionine : cystine ratio (M:C) of 13:1 (Allison and Fitzpatrick 1960) in comparison with maize grains, decorticated cottonseed meal and wheat bran with M:C ratio of 1:1,0.50:1 and 0.33:1 respectively (Morrison, 1961). Urinary S excretion percentages were 49.4, 30.3, 27.8 and 19.60 for the casein-wheat straw ration and the three mentioned feedstuffs respectively. These results are in full agreement with those found by Hashino *et al.* (1963) who reported that the increase of M:C ratio caused a greater urinary S excretion.

2. The addition of casein which was relatively rich in total S when compared with the other tested feedstuffs might cause a greater absorption of S than the animals need.

The excess amount of S absorbed was excreted in urine. The increase in urinary S excretion would cause a decrease in N contents of the urine (Hashino *et al.*, 1963). The end product of these two factors would be a narrower N:S ratio in urine. The results of N:S ratio obtained here were similar to those of El-Gindi (1966) who reported that urinary N:S ranged between 9.3 and 14.1. On the other hand, Wellers and Chevan (1959) reported that there is no strait parallelism between the excretion of N and S.

The amount and the percent of S excretion in the present work were in agreement with that of El-Gindi(1966) who reported that the amounts were lied between 0.62 and 1.22 g/day during the green season and between 0.42 to 1.04 g/day during the dry season. The data indicated that the main pathway for S excretion was the faeces. The results were in agreement with those of Wellers (1959), Knoppen and Krampitz (1963) and Landis (1963) who reported that most of S^{35} was excreted in the faeces(60-88.5%). On the other hand, Kulwich *et al.* (1954) and Faster and Davis (1962) reported that S amount recovered in the urine were 62.5 to 72 %.

The positive S balance in all the trials indicated that the tested common Egyptian feedstuffs provided the animal's need of sulphur and under normal feeding practice no sulphur defficiency problem would be expected.

The correlation between N and S retention on the basis of either body weight or metabolisable body weight showed no relation between them.

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دراسة الكمية المختزنة من الكبريت بواسطة الأغنام

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أجريت ١٤ تجربة هضم على الأغنام لدراسة مدى حصول الحيوان على حاجته من الكبريت عند التغذية على مواد العلف الشائعة فى مصر كذلك طرق اخراج الكبريت والكمية المختزنة بجسم الحيوان .

وشملت الدراسة مواد العلف الخضراء ومواد العلف الخشنة الجافة والحبوب ومخلفات المصانع والمطاحن وحسبت حاجة الأغنام من البروتين والطاقة ، وغذيت على علائق تكفى لحفظ ميزان الأزوت محايدا خلال فترة التجربة ولقد أظهرت النتائج احتواء كسب بذرة القطن المقشور والحشة الثانية من البرسيم على نسبة عالية من الكبريت بينما احتوى رجيع الكون وحبوب الذرة على أقل كمية من الكبريت .

ولقد كان ميزان الكبريت موجبا بالنسبة لكل مواد العلف المختبرة واحتوى روث الأغنام على أعلى كمية اخرجت من الكبريت وحققت اضافة الكازين الغنى فى الكبريت زيادة الكمية الخارجية من هذا العنصر فى البول وحقق النيتروجين والكبريت الخارجة فى البول .