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THE MAINTENANCE REQUIREMENT OF ENERGY (SV or TDN) FOR MATURE SHEEP IN PROLONGED FEEDING TRIALS

By

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Four experiments with 5 mature Ossimi rams and 5 Rahmani ones fed individually on different levels of clover hay A (4 treatments), clover hay B (3 treatments), clover hay B + wheat straw (3 treatments) and clover hay C (3 treatments) were undertaken to find out the suitable level which would maintain body weight for a prolonged period of 12 weeks. The feeding value (SV, TDN and DP) of the feeds was determined in four digestion trials including N-balance with duplicate mature sheep, N-balance insured that rations included more than required for experimental sheep from digestible protein for maintenance.

Results indicated that 0.90 kg. hay A (276.3 g. SV, 451.3 TDN), 0.90 kg. hay B (267.0 g. SV, 445.8 g. TDN) and 0.75 kg. hay B + 0.25 kg. wheat straw (279.5 g SV, 465.2 g. TDN) are mininum energy level for mature sheep of ca. 18 months old of 37.0 to 41.2 kg. At more advanced age (2.5 years), a level of 1.00 kg. hay C (317.9g. SV, 500.6 g. TDN) was necessary for maintaining the same sheep when having heavier weights of 53 to 56 kg. The average requirements per unit metabolic body size ($Wkg^{0.75}$) were 17.8 g. SV or 29.2 g. TDN at younger ages of lower weights, being lower (15.8 g. SV or 24.8 g. TDN) with old sheep having higher weights. Kellner's crude fibre deduction (0.58 SV/unit crude fibre in roughages) was criticized, suggesting reducing it to one third (0.20 SV/unit crude fibre) when calculating SV for maintenance with roughages and not for fat production.

For maintaining mature sheep a range of 310 to 582 g. starch value (SV) per day was recorded (310 g., Ghoneim *et al.* 1960 ; Breirem, 1947 ; 485.2 Watson, 1949 ; 550 g., Ghoneim, 1967 ; 567 g., Woodman *et al.* 1937 ; 571 g., Wood and Capstic, 1926 ; and 582 g., Evans, 1960). As total digestible nutrient (TDN), Brody *et al.*, 1934, recommended 320 g. Garret *et al.*, 1959, 520 g. and the N.R.C. (National Research Council, U.S.A.). by Pope *et al.*, 1957 being 590. A range of digestible organic matter (DOM) of 320 to 516.4 g. was recommended (Longland *et al.*, 1963) ; Lamborne and Readon, 1963 ; g. was recommended (Longland *et al.*, 1963; Lamborne and Readom, 1963 ; and Butterworth, 1966.)

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Regarding the basal metabolism (BM), Kleiber's figure, 1961 of 70 Kilocal per unit Wkg. $^{0.75}$ has wide acceptance. Allowing for activity ca. 33% more are recomended for ruminants by Maynard and Loosli, 1956, being 93 Kilocal. Such recommendation transferred to starch value would be 25 grams (assuming 3761 kilocal. metabolizable energy per 1 kg. SV) as deduced by Abou-Raya, 1967. being 387.5 g. for a standard sheep. Blaxter. 1962, indicated that the daily fasting energy metabolism of mature sheep is 58 Kilocal/Wkg. $^{0.73}$ considering that for maintenance 35% more are required, *i.e.* 77 Kilocal being lower than postullated by Maynard and Loosli.

Experimental and Methods

Five adult Ossimi sheep and five Rahmani ones were fed for suitable successive periods on rations starting with *ad libitum* level. Feed restriction was adjusted to the energy level as starch value which would keep constant body weight, in order to find out the minimum level suitable for maintenance. In all feeding trials, it was intended to keep the digestible protein level not less than necessary for maintenance as judged by certain high standards.

Each sheep was kept alone tied by the neck with a loose rope and fixed to the ground in a small fenced area. After each feeding the sheep was set free in the small fenced area for a certain time. Each sheep had its seperate food compartment and water vessel.

Each sheep was weighed at morning before offering food at biweekly intervals in two successive days. The two weights were averaged to the nearest 0.5 kg. The average gain in each treatment was determined; its significance from zero gain was tested statistically (nul hypothesis).

The feeding-stuffs offered, from those more economically used for maintenance, included clover hay alone or along with wheat straw. The hay was cut into small pieces to be more easily used. Table 1 illustrates the design of the four experiments using four rations and different levels. The same sheep were used in all experiments. Expt. 1, 2 and then 3 in 1965 and 4 in 1966.

In each experiment the feeding value SV, TDN and DP of the ration and N-balance were determined seperately with two sheep in the metabolic cages using the level of the last suitable treatment in each experiment (treatment 4, 7, 10 and 13). The feeding value of wheat straw was determined indirectly using hay B as a basal ration (treatmen 7).

TABLE 1.– THE SUITABLE ENERGY LEVEL FROM THE FOUR RATIONS AND THE DIFFERENT LEVELS WITH MATURE SHEEP.

Treatment No.	Amount of feed kg.	Average initial weight		Energy level		DP g.	Experimental period week
		Ossimi kg.	Rahmani kg.	SV g.	TDN g.		
	Expt. 1.– Hay A (30.70% SV, 50.14% TDN and 8.80% DP)						
1	1.25	37.6	39.4	383.75	626.75	110.00	2
2	1.00	38.3	40.2	307.00	501.40	88.00	2
3	0.75	39.5	41.8	230.25	376.05	66.00	2
4	0.90	37.6	39.1	276.30	451.26	79.26	12
	Expt. 2.– Hay B (29.67% SV, 49.53% TDN and 10.43% DP)						
5	1.00	37.5	39.0	296.70	495.30	104.30	2
6	0.80	37.9	39.0	236.76	396.24	83.44	2
7	0.90	37.1	38.9	267.03	445.77	93.01	12
	Expt. 3.– Hay B + wheat straw (22.81% SV, 37.49% TDN Hay : Straw and 2,53 DP)						
8	0.75 0.30	37.0	39.0	290.96	513.95	85.81	2
9	0.75 0.15	37.9	40.5	256.76	442.71	82.01	2
10	0.75 0.25	34.4	41.0	279.54	465.20	84.57	12
	Ext. 4.– Hay C. (31.79% SV, 50.06% TDN and 10.05% DP)						
11	0.90	54.0	56.0	286.11	450.54	90.45	2
12	1.10	52.0	55.0	349.69	550.66	110.55	2
13	1.00	53.0	56.0	317.90	500.60	100.50	12

Results and Discussion

The feeding value of used rations :

The feeding value of the three hays (table 2) was approaching the average feeding value of clover hay in Egypt as recorded by Khafagi, 1967. The three hays could be considered of midium quality, having a feeding value of 30.70, 29.67 and 31.79% SV in hay A, B and C respectively. The feeding value of the straw (23.81% SV) was the same as published in Egypt (Abou-Raya, 1967). The N retention was positive being 5.71, 9.00, 9.31 and 8.01 gN per day in hay A, B, C and hay B : wheat straw mixture respectively indicating the adequancy of N in rations.

TABLE 2.—ANALYSIS (*a*%), DIGESTION COFFICIENT (*b*%), N-BLANCE AND FEEDING VALUE OF THE FOUR USED RATIONS, EXPT. 1–4.

Item	Hay A		Hay B*		Hay C		Wheat straw	
	a	b	a	b	a	b	a	b
Analysis and digestion coefficients %:								
Moisture . . .	9.38	—	9.53	—	10.42	—	7.06	—
CP	12.77	68.95	14.58	71.54	15.43	65.10	5.58	45.37
EE	4.57	72.32	3.50	58.03	2.16	39.53	2.04	71.85
CF	30.67	53.01	31.96	54.59	30.10	60.64	24.21	52.50
NFE	26.30	67.17	26.00	65.69	30.96	64.41	47.13	40.25
Ash	16.21	—	14.43	—	10.93	—	13.98	—
Feeding value as fed %:								
DP	8.80		10.43		10 05		2.53	
SV	30.70		29.67		31.79		22.81	
TDN	50.14		49.53		50.06		37.81	
Aver. Wt. of 2 sheep kg.	59.50		55.50		60.00		60.00	
Level of feed g.	900.		900.		1000.		750 hay B + 250 straw	
Level of CP g.	114.95		131.25		154.35		123.32	
Level of DP g.	79.26		93.90		100.50		84.57	
Aver. of N † retained g .	5.71		9.00		9.31		8.01	

* Obtained by the difference method using hay B as basal ration.

† N. retention for the mixture.

The gains during the 6 bi-weekly intervals of this final treatment showed no significant gain as follows :

Interval	1st	2nd	3rd	4th	5th	6th
Ossimi, gain, kg. .	–0.3	–0.1	–0.1	0.5	0.0	0.1
$\pm S_{\bar{x}}$	0.41	0.37	0.37	0.64	0.16	0.66
Rahmani, gain, k.g.	0.2	0.3	0.0	–0.1	–0.5	–0.8
$\pm S_{\bar{x}}$	0.76	0.5	0.0	0.19	0.5	0.64

Suitable feed level for maintaining mature sheep :

Results in Expt. 1 (Table3) using hay A started with a preliminary treatment No. 1 feeding an *ad libitum* level of 1.25 kg. hay, indicated an average slight increase in both groups of Ossimi and Rahmani. Reducing

TABLE 3.—AVERAGE GAIN IN WEIGHTS OF SHEEP IN DIFFERNT EXPERIMENTS AND TREATMENTS WITH DIFFERENT FEED LEVELS

	Ossimi			Rahmani		
	Av. Final W	Av. $\bar{X}$	gain $S\bar{x}$	Av Final W	Av. $\bar{X}$	gain $S\bar{x}$
Expt. 1.—Hay A Initial W. in Tr. 1,37.6 kg. for Oss. and 39.4 for Rah.						
Tr. 1, 1.25 kg.	38.3	0.7	+0.30	40.2	0.80	0.58
Tr. 2, 1.00 kg.	39.5	1.2	+0.33	41.8	1.60	0.91
Tr. 3 (0.75) kg.	36.8	-2.7	+0.20	38.0	3.80	0.79
Tr. 4,a 0.90 kg.	37.3	-0.3	+0.41	39.3	0.20	0.76
Tr. 4 b, 0.90 kg.	37.5	-0.1	+0.39	39.2	0.10	0.30
Expt. 2.—Hay B Initial W. Tr. 5,37.5 kg. for Oss. and 39.0 for Rah.						
Tr. 5, 1.00 kg.	37.9	0.4	0.18	39.0	0.5	0.27
Tr. 6, 0.80 kg.	37.2	-0.7	0.25	38.0	-1.0	0.50
Tr. 7 *a*, 0.90 kg.	37.0	-0.1	0.29	39.2	-0.3	0.46
Tr. 7 *b*, 0.90 kg.	37.0	-0.1	0.40	38.9	0.1	0.24
Expt. 3.—(0.75 kg. Hay B + Sraw) Initial W. on Tr 8,37.0 kg. for Oss. and 39.0 for Rah.						
Tr. 8, Hay + 0.3 kg.straw	37.9	0.9	0.29	40.0	1.0	+34
Tr. 9, Hay + 0.15 Straw	37.7-	0.2	0.37	40.0	-0.5	0.16
Tr. 10 *a* Hay + 0.25 Straw	37.8	0.4	0.19	40.8	-0.2	0.20
Tr. 10 *b* Hay + 0.25 Straw	37.4	0.0	0.11	41.0	0.0	0.22
Expt. 4.—Hay C Initial W. on Tr 11 54.0 kg. for Ossi and 56.0 for Rah						
Tr. 11, 0.900 kg.	52.5	-1.5	0.31	55.0	-1.0	0.16
Tr. 12, 1.10 kg.	53.0	0.5	0.22	55.8	0.8	0.34
Tr. 13 *a*, 1.00 kg.	53.1	0.1	0.46	55.9	0.1	0.19
Tr. 13 *b*, 1.00 kg.	53.0	0.0	0.25	56.1	0.1	0.25

(*a*) After 2 Weeks, (*b*) after 12 weeks,

($\bar{X}$, $S\bar{x}$) mean and its error,

the hay level to 1 kg. in the 2nd treatment indicated a significant increase with Ossimi and insignifcant with Rahmani (t=3.64 and 4.47 in the respective groups). But following further reduction in treatment 3 to 0.75 kg. hay resulted in highly significant reduction in weight. Raising the hay level to 0.90 kg. in (Tr 4) did not result in any significant gain either after 2 weeks feeding (Tr. 4*a*) or after prolonged feeding for 12 weeks (Tr. 4*a*). It was therefore concluded that under the condition of the experiment, 900 g. hay A (276.3 g. SV or 451.3 g. TDN) would maintain the live weight of mature sheep having an average of 37.5 and 39.1 kg. weight in Ossimi and Rahmani sheep respectively.

Results in Expt. 2 with hay B with the same two groups of sheep confirmed those in Expt. 1. One kg. hay in (Tr. 5) showed an increase in 6 animals and no gain in 4. Reducing the level to 0.80 kg. hay (Tr. 6) showed almost significant decrease with Ossimi (0.7 + 0.25 kg., t = 2.8). Restoring the level to 0.9 kg. kept the weight constant in both groups after 2 weeks or a prolonged period of 12 weeks (Tr. 7 *a* and *b*). The intermediade gains during the bi-weekly intervals of this final treatment were not significant. Here 0.90 kg. hay B (267.0 g. S.V. or 445.8 g. TDN) could be considered a minimun feed level which maintain constant live weight of 37.0 and 40.0 kg. of Ossimi and Rahmani sheep respectively.

In Expt. 3, (Tr. 8 *a*) constant level of 0.75 kg. hay B was offered along with 0.30 kg. wheat straw (Tr. 8) intending to replace straw with some of the clover to reduce feeding cost. A significant increase in weight of both groups was noticed. Reducing the straw to 0.15 kg. in (Tr. 9) a decrease in weight occured in both groups being significant with Rahmani. Raising the straw to 0.20 kg. in Tr. 10, did not show any significant gain after 2 weeks (Tr. 10 *a*) or during the whole 12 weeks (Tr. 10 *b*) as well as at any intermediate bi-weekly intervals of Tr. 10. Therefore, a level of 0.75 kg. hay B + 0.25 kg. wheat straw (279.5 g. S. V. or 465.2 g. TDN) could be considered as a minimun level to restore the weight of adult sheep having an average weight of 37.4 kg. in Ossimi and 41.0 kg. in Rahmani. Results being similar to those in Expt. 1 and 2.

In Expt. 4 which was undertaken with the same groups of sheep in the next year, but when having a higher live weight (53 56 kg.), the level 0.9 kg. hay C was tested in Tr. 11 for comparison with the same level of hay A and B in Expt. 1 and 2 given with lower live weight. In both groups, a significant decrease in weight occured (1.5 $\pm$ 0.31 kg., t = 4.83 with Ossimi and 1.0 $\pm$ 5.16 kg., t = 6.25 with Rahmani). Increasing the level to 1.10 kg. in (Tr. 12) showed a slight increase in weight in both groups approcahing the level of significance. But when reducing the level to 1.0 kg. (Tr. 13) restored the weight of both groups after 2 weeks (Tr. 13 *a*) or after 12 weeks (Tr. 13 b). During the intermediate bi-weekly intervals of Tr. 13, no significant change in weight was achieved. Therefore, heavier weights of sheep (53 kg. from Ossimi and 56 kg. from Rahmani) needs higher level of feed intake for maintenance, the lower limit being 1.00 kg. hay C equivalent to 318.9 g. S.V. or 500.6 g. TDN.

Summarizing the results of the four final prolonged treatments in the 4 experiments, the calculated energy level per unit Wkg.$^{0.75}$ and the standard sheep (45.3g., having metabolic body size of 17.5) would be :

Expt.	Average	Weight	Food Level per unit 0.75 Wkg.		Food level per standard sheep	
			S.V.	T.D.N.	S.V.	T.D.N.
1	Oss. . . .	37.0	18.24	29.80	319.2	521.5
	Rah. . . .	39.1	17.71	28.20	309.9	493.5
2	Oss. . . .	37.0	17.80	29.72	311.5	520.1
	Rah. . . .	40.0	16.79	28.00	293.8	490.0
3	Oss. . . .	37.4	18.48	30.77	323.4	538.5
	Rah. . . .	41.0	17.25	28.71	301.8	302.4
4	Oss. . . .	53.0	16.22	25.54	283.8	447.0
	Rah. . . .	56.0	15.50	24.42	271.2	427.4

It was clear that results in Expts. 1, 2 and 3 were similar in magnitude tending to be slightly higher with Ossimi which have a slightly lower live weight. Such differences could be neglected. Therefore, it could be concluded that with an average weight of 37 to 41 kg. sheep of ca. 18 months old) an average of 17.8 g. SV or 29.2 g. TDN are minimum maintenance requirements for each unit Wkg.$^{0.75}$ the corresponding figures for a standard sheep being 311.5 g. SV and 511.0 g. T.D.N. The S.V. figure was below the range published abroad, the lower figure being that of Bereirem, 1947 (359.0 g.) and the highest of Evans, 1960 (582 g.). The figure obtained here is similar to that of Ghoneim *et al.*, 1960 (310 g. S.V. for 1 year old Egyptian sheep.

With the same sheep at more advanced age (ca. 2.5 years) having average weights of 53 kg. with Aussimi and 56 kg. with Rahmani, it was obvious that the energy level needed for maintenance per unit Wkg.$^{0.75}$ appeared to decrease with advancing age. It could be concluded that for an average live weight of ca. 55 kg., and average of 15.80 SV or 24.80 TDN per unit Wkg.$^{0.75}$ is necessary for maintenance, the corresponding figure for a standard sheep being 275.0 g. SV or 435.0 g. TDN.

In this connection Blaxter, 1965, page 432, discussing the choice of one metabolic body size with Kleiber, 1961, indicated that with advancing age in sheep metabolism per kg. metablic size decreases. This was in accordance with the results here. Sheep at younger age (37—41 kg.) was maintained relatively on a higher energy level per unit metabolic body size than when they were at an advanced age (ca. 55 kg. W).

It is also to be noted that the figure 29.5 g. TDN for maintaining one unit of Wkg. $^{0.75}$ deduced from the equation of Garret *et al.*, 1959, was very the same as that obtained here (29.2 g. TDN) in the first three experiments with sheep having an average weight from 37.0 — 41.0 kg.

It was found in this Department by Khafagi, 1967, studying the digestible energy DE of 16 clover hays in Egypt, (using direct determination in the bomb calorimeter), that the average DE/g. TDN was equal to 4.33 kcal. Therefore, the DE suitable for maintaining one unit Wkg. $^{0.75}$ in this study would be 126.4 kcal. This figure was slightly lower (8.4% less) than that stated before by Garret *et al.*, 1959 (138 kcal).

Moreover, it was noticable that the SV figure obtained here with standard sheep was relatively much lower than the highest one recorded in the literature being 311 against 582, ca. 53% of it. But the TDN figure (515 g. against 590 g.) was 87% of the highest figure of the range.

The reason for this appeared to be due to the fact that Kellner's starch value (usually calculated for fat production) underestimates the feeding value of roughages when used for maintaining animals. This subject was discussed by Evans, 1960, stating that Kellner's SE for hays and straws should be increased by one fifth as already suggested by Wood. He mentioned that Armsby's net energy figures of coarse fodder were distinstly higher than Kellner's ones which underevaluate the productive values of such feeds.

In this connection, Brouwer *et al.*, 1965, mentioned that Kellner deduction of crude fibre (2.2 Kcal per gram crude fibre) in metabolisable energy for fat production appeared to be ca. three times greater than what they found for maintenance using respiration chambers. Their deduction figure was 0.72 kcal per gram crude fibre. In other words, those authors indicate that the crude fibre deducations in starch value unit used by Kellner (0 58 unit SV unit crude fibre) should be reduced to one third, *i.e.* ca. 0.20 unit SV, to calculated starch value of hays for maintenance. This appeared to be physiologically logical because the heat produced from that called "work of digestion" in fat production, would be wasterful. For maintenance it could be fully utilized raising the relative feeding value for maintenance. The same idea was indicated by Abou-Raya, 1967, suggesting 0.20 unit SV deduction per unit crude fibre in hays when calculating the feeding value for maintenance. For example, the feeding value of hay A calculated by Kellner's method as 30.7% SV, should be 42.3% SV when used for maintenance. The increase in feeding value would be 37%. Therefore in expt.

1 for Ossimi sheep, the starch value figure for a standard sheep (317.4 g.) would be 438.0 g., a figure which would be ca. 75% of the maximum figure for standard sheep (582 g.) given by Evans, 1960.

From the previous studies, it was clear that under similar conditions with Egyptian sheep, the minimum energy requirements for maintenance from clover hay (having a feeding value of ca. 30% SV or ca. 50% TDN, the DP being 8% or more) could be covered by 900 g. hay at the age of ca. 18 months (having weights of ca. 40 kg.) and by 1000 g. hay at advanced age (ca. 2.5 years weighing ca. 55 kg). This level would keep the weight of the animal practically constant provided the animals were fed indoors and somewhat confined in narrow pens. The 900 g. of the clover hay could be replaced by 750 g. clover hay and 250 g. wheat straw reducing feeding cost.

Further experiments under other conditions using feed mixtures including concentrates are needed to gain more informations about the sutiable levels for maintaining sheep.

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احتياجات الطاقة (معادل نشا أو مركبات مهضومة كلية) من الغذاء الحافظ للأغنام التامة النمو من تجارب التغذية لفترة ممتدة

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الملخص

اجريت أربع تجارب على خمسة كباش أوسيمى وخمسة رحمانى تامة النمو غذيت فرديا على مستويات مختلفة من دريس البرسيم أ (٤ معاملات) ودريس البرسيم ب (٣ معاملات) ودريس البرسيم ب مع تبن القمح (٣ معاملات) ودريس البرسيم جـ (٣ معاملات) وذلك لمعرفة أنسب مستوى غذائي يحفظ وزن الحيوان ثابتا لمدة ممتدة الى ١٢ أسبوعا. وقد قدرت القيمة الغذائية (معادل نشا م . ن ومركبات مهضومة كلية م.م.ك وبروتين مهضوم) لهذه الأغذية المستعملة فى ٤ تجارب هضم مع زوج من الكباش التامة النمو مع تقدير لميزان الآزوت الذى أكد أن الأغذية تحتوى على مستوى أعلى من احتياج حيوانات التجارب من البروتين المهضوم الحافظ .

وبينت الدراسة أن ٠ر٩٠ و. كجم دريس أ (٣ر٢٧٦ جم م . ، ٣ر٤٥١ م.م.ك) أو ٠ر٩٠ كجم من دريس ب (٠ر٢٦٧ جم م . أو ٨ر٤٤٥ جم م.م.ك) أو ٠ر٧٥ كجم دريس جـ مع ٠ر٢٥ كجم تبن قمح (٥ر٢٧٩ جم م . ن أو ٢ر٤٦٥ م.م.ك) تعتبر أقل مستوى طاقة مناسب لكباش تامة النمو عمرها نحو ١٨ شهرا أو متوسط وزنها من ٣٧ الى ٤١ كجم ، بينما عند الأعمار المتقدمة (٥ر٢ سنة) يلزم مستوى ١ر٠٠ كجم من دريس جـ (٩ر٣١٧ جم م.ن أو ٦ر٥٠٠جم م.م.ك) كحد أدنى يناسب العليقة الحافظة لكباش أعلى فى الوزن من ٥٣ الى ٥٦ كجم . وقد وجد أن متوسط هذه الاحتياجات منسوبا لكل وحدة حيز جسم تمثيلى (٧٥ر٠ كجم) يبلغ ٨ر١٧ جم م.ن أو ٢ر٢٩ جم م.م.ك عند السن الأصغر ذى الوزن الأقل بينما عند السن الأكبر والأعلى فى الوزن نقص هذا المقدار الى ٨ر١٥ جم م.ن أو ٨ر٢٤ جم م.م.ك .

كما انتقد مقدار خصم الألياف لكليبر (٥٨ر٠ م.ن لكل وحدة الياف خام فى الأغذية الخشنة الجافة) ، واقترح تخفيضه للثلث (٢٠ر٠ وحدة م.ن لكل وحدة الياف خام) عند ما يحسب القيمة الغذائية للمواد الخشنة للتغذية للعليقة الحافظة وليس لانتاج الدهن .

(١) فرع تغذية الحيوان ـ قسم الانتاج الحيوانى ـ كلية الزراعة ـ جامعة القاهرة .

(٢) قسم تغذية الحيوان ـ الادارة العامة للانتاج الحيوانى ـ وزارة الزراعة الدقى ـ ج . ع . م .