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FEEDING MANAGEMENT AND THE PERFORMANCE OF SHEEP IN SOUTHERN SINAI: 1. DIET SELECTION AND THE VOLUNTARY FOOD INTAKE OF EWES

Farid, M.F.A.; H.S. Khamis; E.Y.A. Eid and A. Helal
Animal Nutrition Department, Desert Research Centre, Al-Matareya, Cairo, Egypt.

ABSTRACT

An experiment was carried out to quantitatively characterize production and reproduction traits of local sheep in southern Sinai and to standardize the nutritional management of sheep flocks. Since the nutritional requirements of the local breeds are not known, it was empirical to study diet selection and voluntary food intake and its regulation during different stages of the production cycle.

A total of 85 ewes in four groups were used. A control group was fed according to the NRC standards. Control rations were balanced using the same ingredients offered to the experimental groups. Ewes in the three experimental groups, group-housed in shaded pens, were offered one of three basal roughages; berseem hay, one-third berseem hay and rice straw, and rice straw with added molasses-urea feed mixture. Roughages were made available *ad lib* and comprised the sole ration during breeding and early pregnancy. A flushing concentrate was fed to all ewes including the controls before and during breeding at the rate of 200 g/day/ewe. As of the start of the late pregnancy period and up to the weaning of the offspring, the three experimental groups were offered, in separate feeders, ground corn grains and cottonseed meal to allow for free-choice intake. Group food intakes were recorded daily and live body weights biweekly.

The hay-fed ewes were able to select diets that satisfied their energy and protein requirements during the different stages of the production cycle. The physical characteristics of the selected diets in terms of roughage and crude fibres percentages in the total DMI and the proportion of dietary protein that is potentially degradable in the rumen were practically the optimum. It appears that in those ewes voluntary food intake regulation was predominantly under the control of physiological factors to satisfy energy requirements. The physical limitation of the fill capacity was not a factor.

The straw-fed groups, on the other hand, failed to control their intake as per their physiological needs. Their voluntary food intake was apparently under the control of physical rather than physiological factors, i.e. the limited fill capacity and the slow rates of degradation and passage of ingested material. The massive increase of Energy requirements during early lactation obliged the ewes to consume large quantities of corn grains. Consequently, their roughage and crude fibres intake was below physiological optimum and the rumen environment and microbial population as well as the host animal might have been adversely affected.
Keywords: Feeding management, Diet selection, Food intake regulation, Sheep.

INTRODUCTION

The different production traits of local sheep are poorly documented and productivity is often presumed low which we believe a misconception. Several factors contribute to this unrealistic idea. Prominent among these is the fact that in Egypt there are no well defined production systems that would provide reliable information on the productivity of the animal commensurate with its inherent genetic potential and the needs, nutritional and managerial, required to realize this productivity. Consequently, and in the absence of accepted feeding standards for the local breeds, feeding is based on experience or on foreign feeding standards. Furthermore, the specific nutritional and physical characteristics of diets suitable for feeding the ewe during the different phases of its production-reproduction cycle seldom receive due consideration. In addition, the management of feeding, i.e. the human and logistics elements are often overlooked disregarding their detrimental role to the sheep production enterprise. The supplementary feeding of sheep grazing arid and semi-arid rangelands is a different story but with the same consequences in practice.

The present experiment was carried out in an attempt to quantitatively characterize the production and reproduction traits of local sheep in southern Sinai under conditions where nutrition is not a limiting factor. This was realized through feeding one experimental group according to the American feeding standards (NRC, 1985). The other experimental groups were allowed free-choice intake from two concentrates; corn grains and cottonseed meal, and a roughage; berseem (*Trifolium alexandrinum*) hay, hay and rice straw, or straw with added a molasses-urea feed mixture, Mufeed, according to treatments described below. This paper present results on free-choice voluntary food intake and intake characteristics. The negative effects of unprofessional feeding management will receive due consideration. Treatment effects on ewe fertility, lactation performance and lamb performance pre- and post-weaning will be presented in succeeding publications.

MATERIALS AND METHODS

Animals and Management

A flock of local sheep at the southern Sinai experiment station at Ras-Sudr was used in the experiment. All breeding females in the flock were included irrespective of body condition, which was below optimum. Only those with defective teeth or udders were excluded. There were 14 yearlings and 71 older ewes. The total of 85 breeding females, in two age categories, was randomly assigned to four groups. Animals were underweight and group averages ranged from 31.2 to 34.7 kg shrunk live body weight. Ewes in moderate conditions should have weighed about 45 kg.

Animals were group-housed in partially shaded pens with ample feeding space for the separate feeding of all four feed ingredients used, i.e. Egyptian clover (Berseem) hay, rice straw, ground yellow corn grains and undecorticated cottonseed meal. Feeds were offered twice daily at 8:00 AM and 4:00 PM as per the four treatments indicated below. Fresh tap water was made available for free-choice drinking once daily after the morning feeding. Shrunk live body weights were recorded biweekly and feed allowances were adjusted as per weight and physiological state in the control (NRC) group. In the other three groups feed ingredients were offered in amounts presumed to allow for free-choice feeding which entails a 5 to 10 percent refusals.

The experiment extended over a total of 42 weeks for ewes till weaning and 24 more weeks for lambs after weaning. It started two weeks before the mating season, which lasted 40 days. Mating was carried out using four fertile and tested rams that were rotated between groups every ten days. Rams were marked on the brisket with colored grease in order to facilitate the recording of mounted ewes. Checks were carried out once daily in the morning and rams were re-greased.

In order to facilitate the management of feeding, the physiological states of the ewe, i.e. early and late pregnancy, and early, late and end of lactation, were calculated assuming day 15 of the mating season as the starting date. It was later adjusted for the purpose of data recording and processing on basis of actual lambing dates. Lambs were weaned in five weekly batches at the age of 16 weeks. During the following 24 weeks, ewe-lambs from all four groups were group-fed to be raised as replacements, whereas ram-lambs were also group-fed and given fattening rations (NRC, 1985).

Experimental Treatments

The control group of ewes was fed according to the American feeding standards (NRC, 1985). Diets were generated using the ARIES software of the University of California, Davis (UCD, 1997). The diets consisted of berseem hay, rice straw, ground yellow corn grains and undecorticated cottonseed meal, plus additives of salt, TM-salt and calcium carbonate.

The three experimental groups were allowed free-choice *ad lib* intake. They differed in the basal roughage fed throughout the experimental period from before breeding till the weaning of the offspring. Those were: 1- berseem hay *ad lib*, 2- berseem hay equal to one-third the intake of group 1 and rice straw *ad lib*, and 3- rice straw *ad lib* with added a commercial molasses-urea mixture, Mufeed, composed of cane molasses with 4% urea and 1% trace-mineralized salt. It was added to the straw at the rate of 10% w/w, as fed basis.

Because of the starting poor condition of the ewes flushing was extended from two weeks before till the end of breeding. The flushing concentrate was a mixture of ground yellow corn grains and soybean oil meal (4 and 1 parts, respectively) given at the rate of 200 g/day/ewe to all control and treatment groups. It was given in addition to the NRC diet (control group) and to the *ad lib* basal roughage in the other three treated groups.

From the end of breeding till the end of the early pregnancy stage, three months from day-15 of breeding, ewes in the three treated groups received only the basal roughage. As of the start of the late pregnancy stage and up to the end of lactation, the three experimental groups were offered *ad lib*, in separate feeders, ground corn grains and cottonseed meal to allow for free-choice intake. Mineral additives were added to both the grains and the meal at the rate of 1% limestone and 0.5% each of common and trace-mineralized salt.

Weaning of offspring was carried out at the age of 16 weeks and in five weekly batches. Ewe-lambs were intended for replacements whereas ram-lambs were fattened. Details of lambs management and feeding and the results will be presented in a succeeding publication.

The chemical analysis and nutritive value of feed ingredients used throughout the experiment (Table 1) were extracted from the "Arab and Middle East Tables of Feed Composition" (Kearl *et al.*, 1979), supplemented with data on protein and fibre fractions extracted from the database of the ARIES software for calculating sheep rations (UCD, 1997).

Table 1: Nutritive value of feed ingredients, DM basis.

	Egypt. Clover Hay	Rice Straw	Straw-Mufeed mix.[1]	Corn Grains	Wheat Bran	Cotton-seed meal	Soy-bean Meal	Flush. Conc.[2]
DM, %	89.00	90.00	88.50	89.00	89.00	90.00	89.00	89.00
ME, Mcal/kg	1.99	1.48	1.91	3.18	2.35	2.84	3.13	3.14
TDN, %	55.00	41.00	43.90	80.00	65.00	75.00	84.00	81.00
TP, %	16.00	3.20	4.55	9.2	17.10	25.60	49.90	17.34
UIP, %	4.48	1.35	1.27	6.44	4.90	5.48	17.40	8.63
DIP, %	11.52	1.85	3.28	2.76	12.10	19.06	32.40	8.69
CF, %	28.80	35.10	31.60	2.60	11.30	22.55	7.00	3.48
ADF, %	36.00	44.00	39.60	3.00	15.00	29.10	10.00	4.40
NDF, %	46.00	66.00	59.40	9.00	51.00	40.70	13.00	9.60

1. Mufeed is a commercial molasses-urea mix containing 4.0% urea and 1.0% trace-mineralized salt, and added to straw at the rate of 10% w/w, as fed basis.
2. Flushing concentrate was a mixture of ground yellow corn grains (4 parts) and soybean meal (1 part) fed at the rate of 200 g/day/ewe.

Statistical Analysis

Data was statistically analyzed using the GLM procedures of SAS (1990). Analysis of variance was carried out, and the Duncan multiple range test was applied as appropriate to test differences between least square means of the four treatments.

RESULTS

Free-choice Feeding

Free-choice *ad lib* food intake was planned for in order to achieve two main objectives. Firstly, to allow for the evaluation of the maximum productive and reproductive capacity of local sheep in southern Sinai under conditions where nutrition is not a limiting factor and feeding management is optimized. The second objective was to further investigate the hypothesis that ruminants can regulate their voluntary food intake in accordance with their energy and/or protein requirement providing the physical fill is not limiting.

Unfortunately, there were times during the course of the experiment where amounts in store of the two concentrate ingredients, either or both, were not sufficient to insure free-choice *ad lib* intake. As illustrated in Figure 1 using data from the hay group; those were the periods with no feed refusals as allowances had to be restricted. They extended mainly over two periods, weeks 16-21 during late pregnancy and weeks 27-36 during early and late lactation.

Resulting energy and protein intakes of the hay-fed group (Figure 2), and when compared to the NRC requirements, indicated that free-choice feeding enabled the animals to consume enough nutrients except during weeks 28-29 for energy and 25-28 for protein, both during the early lactation period, then during weeks 34-36 for both energy and protein at the start of the late lactation period. However, during late lactation, and since dams and their offspring were housed together and were literally sharing the feed ingredients offered *ad lib*, the increase of energy and protein intakes till weaning reflected the increased intake by the lambs, especially beyond the age of 6-8 weeks.

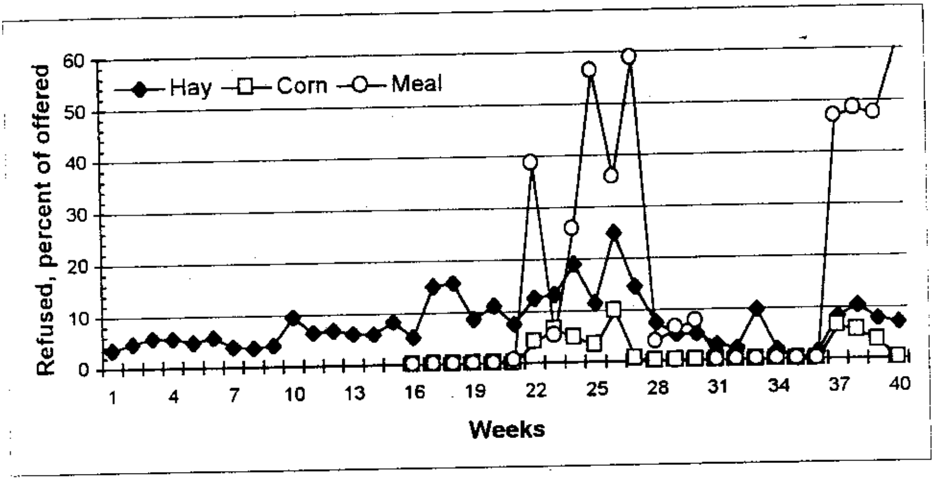

Figure 1: Average weekly feed ingredients refused, percent of offered to ewes in the hay group, from start of breeding till the weaning of offspring.

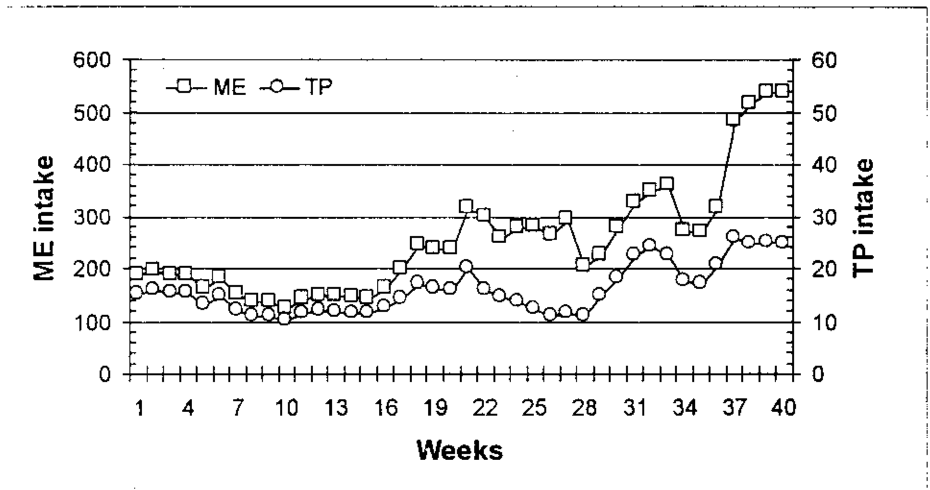

Figure 2: Average weekly energy (ME, kcak/d/kg^0.75) and total protein (TP, g/d/kg^0.75) intake of ewes in the hay group from start of breeding till the weaning of offspring.

Body Condition of Ewes

It is noteworthy to mention that the condition of the ewe at the start of the experiment was well below optimum. Optimum mature body weight of local ewes in good condition is believed to be about 45 kg. When the experiment started two weeks before breeding overall average live body weight was 33.75 kg. Group averages ranged from 31.20 to 34.65 kg (Figure 3). Consequently, the considerable weight gain observed during breeding and the early pregnancy stage was to a large extent a compensation for previous loss of body condition. Noteworthy, animals were offered only *ad lib* roughages during the early pregnancy stage. Hence, those receiving berseem hay gained the most and were similar in magnitude to their control mates, whereas those receiving rice straw plus the Mufeed additive gained

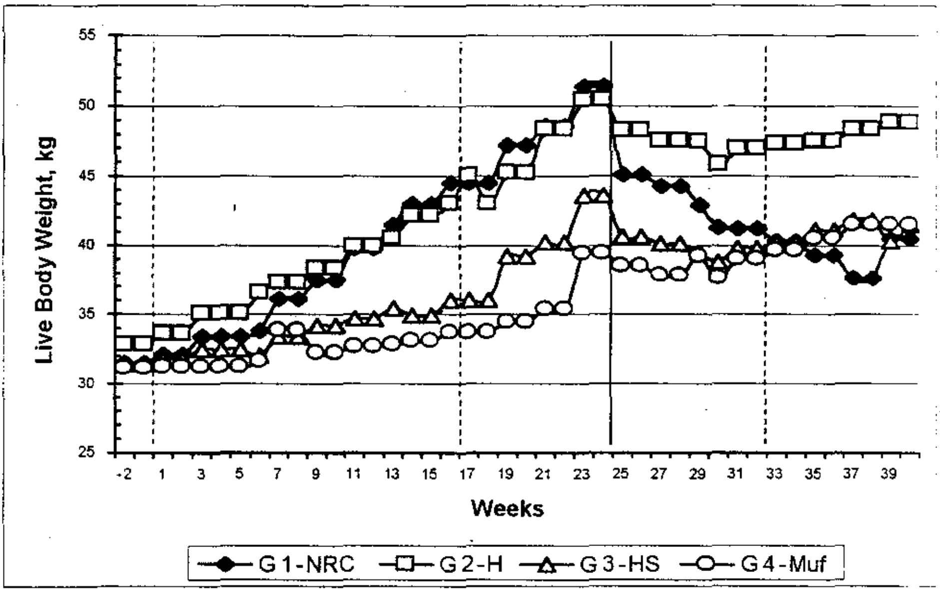

Figure 3: Average weekly live body weight of ewes in the control group and groups offered different basal roughages during the 40-week production cycle.

Average daily weight changes of the four groups during the six stages of the production cycle are presented in Table 2. Data represent averages of 4 weeks from each stage with least interference from the irregularity of feed supply.

At weaning of offspring after 16 weeks of lactation, and excluding barren ewes, average live weights were 50.77 kg in the hay group and 40.71 kg in the control group. The control weighed less since during late lactation there was increasing competition for concentrates by the fast growing lambs beyond the age of eight weeks and feeds offered were regulated. Corresponding average live weights for both the hay-straw and straw-Mufeed groups were 44.21 kg. This subject and the reproductive performance of the ewes will be discussed in more details in a succeeding publication (Farid *et al.*, in preparation).

Food Intake

Average daily dry matter intake, per unit metabolic size and as a percent of live body weight are summarized in Table 2. In general, dry matter intake of all groups increased as the experiment progressed from breeding, going through pregnancy and lactation, and until their lambs were weaned. Also, the concentrates offered during late pregnancy and onward increased dry matter intake appreciably.

Table 2: Live body weight of ewes, weight changes, and dry matter intake during the different stages of the production cycle.

Stage[1]	Weeks[2]	NRC[3] (1985)	NRC Control	Hay group	Hay-Straw	Straw-Mufeed	SEM
Average daily weight change, g/day							
B	2- 5	100.00	53.57^{ab}	76.79^{a}	16.07^{b}	7.14^{b}	20.58
EP	9-12	30.00	137.50^{a}	87.50^{ab}	44.64^{bc}	-8.93^{c}	21.55
LP	17-20	180.00	98.22^{a}	98.22^{a}	132.14^{a}	41.07^{a}	46.30
EL	25-28	-25.00	-1.43^{b}	-5.71^{ab}	-38.10^{ab}	0.00^{a}	19.09
LL1	33-36	45.00	-2.15^{c}	28.57^{b}	51.79^{ab}	60.72^{a}	9.82
LL2	37-40	30.00	91.07^{a}	-0.72^{a}	-3.57^{a}	12.50^{a}	52.18
Dry Matter intake, g/day/kg^0.75							
B	2- 5	98.21	72.48^{b}	83.55^{a}	72.19^{b}	76.74^{ab}	2.388
EP	9-12	66.19	74.06^{a}	69.16^{a}	55.52^{b}	42.82^{c}	2.950
LP	17-20	89.21	75.87^{b}	95.60^{a}	82.61^{b}	73.49^{b}	3.401
EL	25-28	115.11	90.28^{a}	91.88^{a}	95.85^{a}	87.96^{a}	6.187
LL1	33-36	100.77	95.22^{c}	120.72^{a}	102.35^{bc}	116.11^{ab}	4.709
LL2	37-40	66.19	120.24^{b}	195.29^{a}	113.20^{b}	111.58^{b}	5.357
Dry Matter intake, % LBW							
B	2- 5	3.44	3.02^{b}	3.44^{a}	3.03^{b}	3.25^{ab}	0.102
EP	9-12	2.56	2.97^{a}	2.77^{a}	2.29^{b}	1.79^{c}	0.122
LP	17-20	3.44	2.92^{b}	3.70^{a}	3.34^{ab}	3.04^{b}	0.138
EL	25-28	4.44	3.49^{a}	3.49^{a}	3.80^{a}	3.54^{a}	0.244
LL1	33-36	3.44	3.79^{b}	4.60^{a}	4.05^{ab}	4.62^{a}	0.185
LL2	37-40	2.56	4.81^{b}	7.40^{a}	4.46^{b}	4.40^{b}	0.211
Roughage, % DMI							
B	2- 5	85.00	46.91^{d}	81.15^{a}	78.84^{b}	76.98^{c}	0.408
EP	9-12	100.00	59.46^{b}	100.00^{a}	100.00^{a}	100.00^{a}	0.176
LP	17-20	85.00	46.91^{b}	61.70^{a}	51.19^{ab}	37.81^{b}	4.769
EL	25-28	65.00	42.12^{a}	27.82^{b}	19.52^{bc}	14.64^{c}	2.839
LL1	33-36	85.00	50.50^{a}	50.55^{a}	35.34^{b}	13.07^{c}	4.048
LL2	37-40	100.00	51.88^{a}	43.43^{b}	21.33^{c}	10.14^{d}	1.401

1. Stages of the production-reproduction cycle: B = breeding (5 wks), EP = early pregnancy (11 wks), LP = late pregnancy (6 wks), EL = early lactation (8 wks), LL1 = late lactation 1 (4 wks), and LL2 = late lactation 2 (4 wks).
2. Weeks considered to represent regular intake from each stage of the production-reproduction cycle of the ewe.
3. NRC (1985) recommended allowances, included for comparison with observed experimental results.

a-e Least square means, means in a row not sharing a superscript letter were significantly ($P<0.05$) different according to Duncan's multiple range test.

Intake values recorded during the late lactation stages were higher than expected as per values quoted by the NRC (1985). Once again, they represent the total food dry matter intake of the ewes and their offspring. The latter became appreciable beyond the eighth week of age, i.e. during the late lactation stages LL1 and LL2.

The hay group consumed significantly (P<0.05) greater amounts of total dry matter as compared to the two straw fed groups. The straw-Mufeed group consumed the least (P<0.05) total food dry matter throughout. This being true even when concentrates were offered free choice during the LP stage onward.

It was noted that hay feeding significantly (P<0.05) promoted more roughage intake than when ewes were offered hay-straw or straw-Mufeed (Table 2). During early lactation the increased requirements for milk production promoted a further increase in dry matter intake through increased concentrates intake, and the roughage proportion of the diet (R%) fell appreciably. Roughage, %DMI, was considerably low in the straw-Mufeed group, below 14%, during all early and late lactation stages. This is being un-physiologic. On the other hand, R% in the hay and hay-straw groups during early lactation were 28% and 20% of total dry matter intake. The value for the hay group, 28%, is somewhat below the borderline for normal rumen physiological function and specific metabolic requirements for milk production. NRC (1985) recommends a value of 65% total roughage in total dry matter intake, and the control diets used in the present experiment was lowest at 42% during the early lactation stage. For the high producing dairy cow it is around 40% (NRC, 2001), and slightly less in beef cattle (NRC, 1996) and possibly in sheep as well.

Diet Selection

The composition of intake, %DMI, was split between the two roughages and the two concentrates used during the different stages of the production cycle (Table 3). These data illustrate the capacity of sheep for *ad lib* free-choice diet selection under different physiological conditions and when offered *ad lib* basal roughages of widely different nutritive value and concentrate ingredients high in energy or high in protein content.

During breeding and early pregnancy only roughages were offered, along with the limited flushing concentrate, and as indicated earlier hay promoted more roughage and more total dry matter intake. During the late pregnancy stage and as concentrates were introduced free-choice, roughage consumption was high at 62% in the hay group and ewes consumed equal proportions of corn grains and cottonseed meal, 19% each. In comparison, the straw-Mufeed group consumed less roughage, 38%, and increased their intake from the grains and meal, also in equal proportions at 31% each. The hay-straw group was intermediate. Differences between the three experimental groups were statistically significant (P<0.05).

During early lactation roughage intake dropped considerably to 28, 20 and 15 percent of DMI in hay, hay-straw and straw-Mufeed groups, respectively. Intake from corn grains increased to 63, 73 and 74 percent in the three groups, respectively. Meantime, intake from cottonseed meal was low at 9, 7 and 11 percent, respectively. Differences between groups were statistically significant (P<0.05). This is in agreement with the substantial increase in energy requirement at the onset of lactation and throughout the early lactation stage.

Table 3: Intake of roughage and concentrate dietary ingredients (% DMI) during the different stages of the production cycle.[1]

Stages	Weeks	NRC Control	Hay group	Hay-Straw	Straw-Mufeed	SEM
Clover hay, % DMI						
B	2- 5	23.33^{b}	81.15^{a}	21.96^{c}	0.00^{d}	0.140
EP	9-12	31.23^{c}	100.00^{a}	43.37^{b}	0.00^{d}	2.453
LP	17-20	29.37^{b}	61.67^{a}	30.99^{b}	0.00^{c}	2.842
EL	25-28	30.41^{a}	27.81^{a}	15.54^{b}	0.00^{c}	2.002
LL1	33-36	33.23^{b}	50.55^{a}	22.40^{c}	0.00^{d}	2.896
LL2	37-40	37.50^{b}	43.43^{a}	19.54^{c}	0.00^{d}	1.308
Rice straw, % DMI						
B	2- 5	23.59^{c}	0.00^{b}	56.89^{b}	76.98^{a}	0.440
EP	9-12	28.23^{c}	0.00^{b}	56.63^{b}	100.00^{a}	2.475
LP	17-20	17.54^{b}	0.00^{c}	20.20^{b}	37.81^{a}	3.356
EL	25-28	11.72^{a}	0.00^{b}	3.98^{b}	14.64^{a}	1.364
LL1	33-36	17.27^{a}	0.00^{b}	12.94^{a}	13.07^{a}	2.271
LL2	37-40	14.38^{a}	0.00^{c}	1.87^{c}	10.14^{b}	1.178
Corn grains, % DMI						
B[2]	2- 5	23.33^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.000
EP	9-12	33.50^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.657
LP	17-20	38.45^{a}	19.06^{c}	24.27^{bc}	30.92^{b}	2.381
EL	25-28	38.02^{b}	63.37^{a}	73.53^{a}	74.03^{a}	4.534
LL1	33-36	24.61^{c}	29.13^{c}	37.91^{b}	65.29^{a}	2.691
LL2	37-40	23.93^{d}	52.45^{c}	71.96^{b}	82.71^{a}	2.377
Cottonseed meal, % DMI						
B[2]	2- 5	6.43^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.000
EP	9-12	7.05^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.527
LP	17-20	14.64^{c}	19.27^{bc}	24.54^{ab}	31.27^{a}	2.393
EL	25-28	19.85^{a}	8.81^{b}	6.96^{b}	11.34^{b}	2.749
LL1	33-36	24.89^{a}	20.32^{a}	26.75^{a}	21.64^{a}	3.291
LL2	37-40	24.20^{a}	4.12^{b}	6.71^{b}	7.15^{b}	1.414

1. see footnotes, Table 2. Values are least square means and pooled SEM.
2. not including the concentrate mixture used for flushing.

Roughage (R%) increased again during late lactation but only in the hay-fed group (P<0.05). Corn grains decreased, more so in the hay group. Cottonseed meal increased during LL1 but decreased again during LL2 possibly because of the irregular supply of that ingredient. Effect of intake by lambs accompanying their dams in all four groups is recognized but cannot be quantified.

Nutritional Characteristics of Selected Diets

Changing the basal roughage offered *ad lib* to ewes has lead to changes in total and roughage dry matter intake (Table 2). It also changed, qualitatively and quantitatively, the intake from the concentrate ingredients offered free-choice (Table 3). Consequently, the nutritional characteristics of selected diets varied between groups and between stages of the production cycle as well (Table 4).

During breeding and early pregnancy when only roughages ,were offered, in addition to the limited flushing concentrate supplement, energy density (ME, Mcal/kg DMI) was less (P<0.05) in the diets selected by the hay group than that fed to the control group. It further decreased as the proportion of hay in the offered roughage decreased but was greater in the straw-Mufeed than in the straw-hay diets possibly because of the added molasses. Differences between all four groups were statistically significant (P<0.05). Total protein content of selected diets (TP, %DMI) was greatest for the hay group followed by the control. It further decreased in the hay-straw group and was least in the straw-Mufeed group (P<0.05), that is it responded similar to energy density, decreasing as the proportion of hay in the offered roughage decreased.

When the concentrate ingredients were introduced free-choice with the start of the late pregnancy stage, energy density of the selected diets increased, and it increased further during early lactation. Differences between groups attributable to the type of roughage offered decreased and were not statistically significant (P>0.05).

Total protein content of the selected diets also increased during late pregnancy. The hay basal roughage promoted increased total protein content, and it decreased significantly (P<0.05) when straw was included with the hay or when straw-Mufeed replaced the hay. A similar trend was observed during early lactation. However, as the roughage proportion in the selected diets decreased and that of corn grains increased substantially during early lactation, total protein content of selected diets was less than during late pregnancy.

During late lactation, LL1 and LL2, the increase in energy density and total protein content of selected diets reflected the progressive increased intake by the lambs of corn grains and cottonseed meal, and possibly berseem hay as well, between the age of 8 weeks and until weaning at 16 weeks.

It is noteworthy to mention that diets selected by the ewes in the three treated groups and during the six stages of the production cycle had fulfilled the levels of dietary energy and total protein content recommended by NRC (1985); the only exception being the hay-straw and straw-Mufeed groups during the early pregnancy period where no concentrates were offered. This and the difference in response of body condition tend to indicate lowered efficiency of nutrients utilization with decreased roughage nutritive value.

The protein fractions UIP and DIP, as percent of total dietary protein content (Table 4), were calculated using ingredients intake data and tabulated UIP and DIP values (Table 1). It was of interest to note that in the two straw fed groups (hay-straw and straw-Mufeed) during all three lactation stages (EL, LL1 and LL2) the potentially undegraded protein fraction (UIP, %TP), was particularly high exceeding 50% of the total protein content of the selected diets. That lead to a corresponding decrease of the proportion of total protein that is potentially degradable in the rumen (DIP, %TP) to below what is considered optimum for efficient rumen microbial growth, i.e. 60-65%.

Table 4: Characteristics of diets selected by ewes during the different stages of the production cycle.[1]

Stages	Weeks	NRC (1985)	NRC control	Hay Group	Hay-Straw	Straw-Mufeed	SEM
ME, Mcal/kg DMI							
B	2- 5	2.100	2.448^{a}	2.189^{b}	1.923^{d}	2.169^{c}	0.006
EP	9-12	2.000	2.308^{a}	1.993^{b}	1.704^{d}	1.910^{c}	0.014
LP	17-20	2.100	2.485^{b}	2.383^{b}	2.387^{b}	2.595^{a}	0.055
EL	25-28	2.400	2.554^{b}	2.822^{a}	2.907^{a}	2.959^{a}	0.043
LL1	33-36	2.100	2.409^{c}	2.512^{bc}	2.605^{b}	2.943^{a}	0.048
LL2	37-40	2.000	2.410^{d}	2.653^{c}	2.897^{b}	3.030^{a}	0.021
Total protein (TP), % DMI							
B	2- 5	9.10	14.23^{b}	17.79^{a}	10.73^{c}	9.37^{d}	0.093
EP	9-12	9.30	10.79^{b}	16.00^{a}	8.75^{c}	4.55^{d}	0.318
LP	17-20	10.70	12.55^{c}	16.55^{a}	14.12^{b}	12.57^{c}	0.447
EL	25-28	13.40	13.82^{a}	12.54^{ab}	11.16^{bc}	10.38^{c}	0.525
LL1	33-36	10.70	14.50^{ab}	15.97^{a}	14.33^{b}	12.14^{c}	0.498
LL2	37-40	9.10	14.86^{a}	12.83^{b}	11.51^{c}	9.90^{d}	0.318
UIP, % TP							
B	2- 5		34.75^{a}	28.28^{c}	30.92^{d}	28.61^{b}	0.005
EP	9-12		40.10^{a}	28.00^{b}	31.05^{c}	27.91^{b}	0.361
LP	17-20		38.51^{a}	30.48^{c}	32.34^{d}	33.26^{b}	0.176
EL	25-28		36.80^{c}	46.84^{b}	52.76^{d}	53.93^{a}	1.974
LL1	33-36		32.20^{b}	32.90^{b}	35.62^{c}	46.05^{a}	1.393
LL2	37-40		31.92^{c}	43.35^{b}	51.50^{d}	59.14^{a}	0.965
DIP, % TP							
B	2- 5		64.77^{c}	71.72^{a}	69.08^{d}	71.39^{b}	0.005
EP	9-12		59.20^{b}	72.00^{a}	68.95^{c}	72.09^{a}	0.313
LP	17-20		60.26^{c}	68.29^{a}	65.83^{d}	64.13^{b}	0.264
EL	25-28		61,71^{a}	52.45^{b}	46.59^{d}	44.93^{c}	1.822
LL1	33-36		65.98^{a}	65.76^{a}	62.44^{c}	52.08^{b}	1.285
LL2	37-40		66.36^{a}	56.31^{b}	47.90^{c}	40.10^{d}	0.897
Crude fibres, % DMI							
B	2- 5	~ 18	18.48^{d}	24.53^{c}	27.59^{a}	25.74^{b}	0.118
EP	9-12	~ 18	21.36^{d}	28.80^{c}	32.37^{a}	31.60^{b}	0.225
LP	17-20	~ 18	18.92^{b}	22.60^{a}	22.18^{a}	19.80^{b}	0.877
EL	25-28	~ 18	18.34^{a}	11.65^{b}	9.35^{b}	9.11^{b}	1.104
LL1	33-36	~ 18	21.88^{a}	19.90^{b}	18.01^{b}	10.71^{c}	0.795
LL2	37-40	~ 18	21.92^{a}	14.80^{b}	9.64^{c}	6.97^{d}	0.569

1. see footnotes, Table 2. Values are least square means and pooled SEM.

Excessive intake of corn grains by the straw fed groups during the late lactation stages might have contributed to this situation.

Crude fibres content in the free-choice dry matter intake (Table 4) was greater ($P<0.05$) in the straw fed ewes than in their hay fed mates which, in turn, was greater than the control. It decreased during the late pregnancy stage when concentrates were offered and was comparable in all three experimental groups. During the lactation stages and with the increased free-choice intake from the concentrate ingredients especially corn grains to meet the increased energy requirements, crude fibres intake, % DMI, decreased markedly. It was below levels considered optimum for digestive and metabolic functions in the rumen and animal tissues, i.e. approximately 18% or more in DMI.

Energy and Protein Intake from Selected Diets

Table 5 summarizes data on energy and protein intake of ewes per unit metabolic size. Relative intakes, as percent of the NRC (1985) recommended allowances are presented in Table 6.

Table 5: Energy and protein intake from diets selected by ewes during the different stages of the production cycle.[1]

Stages	Weeks	NRC (1985)	NRC control	Hay group	Hay-Straw	Straw-Mufeed	SEM
ME intake, Kcal/day/kg^0.75							
B	2- 5	189.9	177.42a	182.93a	138.80c	166.58b	4.826
EP	9-12	132.3	170.90a	137.83b	94.48c	80.42c	5.483
LP	17-20	189.9	188.55b	228.08a	197.55b	190.34b	11.516
EL	25-28	267.6	230.60a	259.97a	279.80a	259.71a	20.353
LL1	33-36	195.6	229.25c	303.66ab	267.79bc	340.85a	15.559
LL2	37-40	132.3	289.96b	518.25a	328.21b	337.59b	17.225
Total protein (TP) intake, g/day/kg^0.75							
B	2- 5	8.46	10.31b	14.87a	7.74c	7.19c	0.336
EP	9-12	6.22	7.99b	11.07a	4.82c	1.92d	0.260
LP	17-20	9.84	9.52bc	15.83a	11.68b	9.28c	0.714
EL	25-28	12.09	12.50b	11.41ab	10.65b	9.14b	0.729
LL1	33-36	9.84	13.80c	19.30a	14.80bc	14.08a	1.097
LL2	37-40	6.22	17.87b	25.03a	12.98c	11.08c	0.657

1. see footnotes, Table 2. Values are least square means and pooled SEM.

During the execution of the experiment, and by the end of the early lactation stage, it was noted that lambs were significantly competing with the dams for the feed ingredients offered especially the concentrates. Therefore, it was decided not to reduce allowances to the control ewes during late lactation as per the NRC (1985) recommended allowances. Rather, allowances used during early lactation were continued unchanged until the weaning of offspring. This explains the higher energy and protein intake of the control group ewes during late lactation. In proportion to the early lactation allowances, relative energy intake would be 85.7% and 108.4% of the NRC recommended allowances rather than the 117.2% and 289.9% values shown in Table 6. The difference would presumably represent consumption by the offspring. The below recommended intake during early lactation (86.2%) is not readily explainable.

In the three experimental groups and under the conditions of free-choice *ad lib* roughage intake during breeding and early pregnancy, the straw fed ewes failed to consume enough energy and protein to supply their requirements even with the flushing concentrate offered during breeding.

During late pregnancy and early lactation and with the free-choice feeding of concentrate ingredients, ewes in the three experimental groups were able to obtain their required energy and protein requirements as per NRC recommendations. As a matter of fact, it appears that the hay group ewes consumed more energy and protein than their requirements. It is to be noted, however, that diets consumed during early lactation were not physically balanced having very low roughage and crude fibres especially in the straw fed groups. Excess energy and protein consumed during late lactation beyond 100% NRC recommendations is assumed to represent consumption by the offspring (Table 6).

Table 6: Relative Energy and protein intake from diets selected by ewes during the different stages of the production cycle, % of NRC (1985) recommended allowances.[1]

Stages	Weeks	NRC (1985)	NRC control	Hay group	Hay-Straw	Straw-Mufeed
ME intake, %NRC (1985)						
B	2- 5	100.0	93.4	96.3	73.1	87.7
EP	9-12	100.0	129.2	104.2	71.4	60.8
LP	17-20	100.0	99.3	120.1	104.0	100.2
EL	25-28	100.0	86.2	97.1	104.6	97.1
LL1	33-36	100.0	117.2	155.2	136.9	174.3
LL2	37-40	100.0	219.2	391.7	248.1	255.2
Total protein (TP) intake, %NRC (1985)						
B	2- 5	100.0	121.9	175.8	91.5	85.0
EP	9-12	100.0	128.5	178.0	77.5	30.9
LP	17-20	100.0	96.7	160.9	118.7	94.3
EL	25-28	100.0	103.4	94.4	88.1	75.6
LL1	33-36	100.0	140.2	196.1	150.4	143.1
LL2	37-40	100.0	287.3	402.4	208.7	178.1

1. see footnotes, Table 2.

DISCUSSION

Grazing herbivores have been known to select diets that are richer in nutrients and lower in toxins than the average composition of available vegetation (Fontenot and Blaser, 1965; Arnold, 1970). Free-choice feeding of housed animals facilitates the expression of the animals' ability to choose diets with nutrient contents that are commensurate with satisfying its requirements for maintenance and production (e.g. Cropper *et al.*, 1985, 1986; Forbes, 1995; Farid, 1997). In both situations, the voluntary food intake is controlled by the physiological demand for energy due to maintenance needs and potential production requirements, including continued fat deposition in the adult, but only up to the limit of the gastro-intestinal tract (GIT) fill capacity (e.g. Conrad *et al.*, 1964; Montgomery and Baumgardt, 1965 in cattle; and Blaxter *et al.*, 1961; Farid and Hassan, 1976 in sheep). Other nutrients such as protein, amino acids and some minerals, as well as nutritional imbalances, might also play a role (Cooper and Kyriazakis, 1993; Kyriazakis and Oldham, 1993; Fedele *et al.*, 1997; Tolkamp *et al.*, 1998a,b; Phy and Provenza, 1998; Scott and Provenza, 1999, 2000). Additional factors such as appetite, behavior, learning and aversion, and postingestive feedback, may contribute significantly, positively or negatively, to the regulation of voluntary food intake (Mathews and Kilgour, 1980; Provenza, 1995).

The physical elements related to both the animal and its food often limits the full expression of the basic physiological functions. The physical capacity of the GIT is an animal-related function whereas the bulk of the food and its kinetics of digestion and rate of passage are food-related functions (van Soest, 1994; Mertens and Ely, 1979; Forbes, 1995; Farid *et al.*, 1997). Interactions occur between the physiological and physical elements and the realized voluntary food intake is invariably conciliation. Different physiological states of the animal enhance the requirements, e.g. during late pregnancy, but the physical capacity of the GIT is limited by the growing foetus. Also, during the early lactation stage the massive increase in requirements cannot be fulfilled unless diets with un-physiological low fibre (roughage) content are used.

Later, it has been suggested that one objective of diet selection of ruminant animals might be the maintenance of a functionally fit and adaptive rumen. This would assist the animal in achieving the ultimate goal of meeting its requirements for energy and nutrients, and would require certain aspects of the rumen environment to remain within an acceptable, so-called normal range of conditions that are of importance to the resident micro-organisms as well as to the host animal. Cooper *et al.* (1995 a,b) speculated that the rumen conditions that may have significant effects on diet selection of ruminants would be those related to the consequences of fermentation of rapidly fermentable material (resulting in increased acidity and osmolality) and the hydrolysis of rapidly degradable protein (resulting in high concentrations of ammonia in the rumen). They reported that sheep offered a choice between two concentrate foods that differ in their energy density included a considerable proportion of the low-energy food in their diet possibly to balance the increased rumen acidity and osmolality caused by ingesting the high-energy grain foods. This can be modified through the inclusion in the diet of buffers such as sodium bicarbonate (Cooper et al., 1996; James and Kyriazakis, 2002) or increasing the proportion of good quality roughage in the total daily ration. Moreover, Kyriazakis and Oldham (1997) reported that the long-term (daily *vs.* shorter periods during the day) diet selection of sheep could be affected by the degree of synchrony of energy and protein digestion in the rumen. They concluded that sheep select a daily diet from two foods of different rumen degradable protein (DIP) content, which avoids excess of DIP intake, and this depends on the carbohydrate source in the foods.

Different stressful physiological conditions also affect or modify voluntary food intake such as the state of compensatory growth. Following periods of reduced growth in the growing animal, or weight loss in the adult, caused by restriction of food or otherwise by illness or adverse environmental conditions, animals gain at a faster rate than unrestricted ones of the same age (Wilson and Osborne, 1960). This phenomenon is believed the result of increased voluntary food intake, increased weight of gut contents and improved efficiency of food conversion. The latter may be due to reduced maintenance requirements (Forbes, 1995). This was evident in the present experiment where ewes in all four groups were approximately 10 kg or more below optimum weight. Compensatory growth was obvious in the control group during the early pregnancy period (Figure 3). Ewes in the hay group responded similarly and it appears that the physical fill capacity was not limiting their voluntary food intake. However, ewes in the two straw-fed groups, with limited hay or with added molasses-urea (Mufeed) compound, did not experience or benefit from this phenomenon as their intake was limited by the low density of nutrients in the feeds and the fill capacity limitation of the GIT, the latter being a reflection of low rates of digestion and passage of the poorer quality roughage.

When concentrates were offered free-choice during late pregnancy and onward, food intake and weight gain improved in all three experimental groups. Nevertheless, hay-fed ewes maintained their superiority over the straw-fed ones. The present results indicate that the straw-fed ewes attempted to increase their food intake to meet energy (and protein) requirements. In order to overcome the GIT fill capacity limitation they decreased their roughage intake to below physiologically acceptable levels of approximately 18% CF in DMI needed for the normal functioning of the rumen and gastro-intestinal tract and the animals' intermediary metabolism. This is conducive of decreased acetate and increased propionate production in the rumen, rumen acidosis, increased rumen liquor osmolality as well as its adverse effects on the anatomy and function of the rumen papillae and on milk composition. Under these conditions lactating ruminants tend to maintain its milk yield but milk fat (and protein) content and yield decrease and body fat deposition might be enhanced. Furthermore, the concurrent increased concentrate intake, particularly from corn grains, decreased the proportion of total protein that is potentially degradable in the rumen (DIP, %TP) to below what is considered optimum for efficient rumen microbial growth, i.e. 60-65%. The anticipated increased rumen acidity and osmolality will in turn limit voluntary food intake and the efficiency of utilization of ingested nutrients as reviewed above. Urea in the Mufeed group might as well have contributed to limiting the voluntary food intake of this group of ewes through increased rumen ammonia concentration.

Meeting nutrient requirements of ruminants is more than just insuring an abundant supply of nutrients. The synchrony of energy and protein digestion in the rumen and the partitioning of nutrient, starch and protein, digestion between the rumen and the lower tract are of primary concern (Kyriazakis and Oldham, 1997). Several authors (e.g. Stokes *et al.*, 2000; Wand, 2003) provided guidelines for formulating ruminant rations that maximize intake and nutrients utilization. Ration fibre level and fibre particle size contribute to the maintenance of a functionally fit and adaptive rumen. The optimum long roughage proportion in the total diet is 40% in dairy cattle and somewhat less in beef cattle and sheep. This should be at least 1.5 inches long and of good quality. Consequently, a minimum of 18% crude fibres (~ 21% ADF) is needed in the daily ration dry matter intake. Grain processing increases total starch digestion and balance the partitioning of starch fermentation in the rumen and starch digestion in the lower tract. Popular grain processing procedures range from simple grinding to dry rolling and steam flaking, and roasting of oilseeds.

The fundamental rule for protein feeding is not to overfeed. Approximately one-third should be potentially un-degradable in the rumen (UIP). The remaining two-thirds represent the potentially degradable protein (DIP) and are equally split between soluble nitrogen compounds and available protein. Excessive protein intake impairs performance; energy is required for removal of excess nitrogen, increased rumen ammonia concentrations negatively affect voluntary food intake and high blood urea nitrogen may be a factor in sub-optimal fertility (Kane *et al.*, 2004).

These guidelines are to be carefully observed when attempting to develop a feeding management system. In addition, the cardinal factor that will "make or brake" a feeding system is FOOD INTAKE CAPACITY. It is the function of the physical fill capacity and retention time.

The physical fill capacity of the rumen and the whole gastro-intestinal tract limits the maximum amount of food dry matter that can be accommodated. When dealing with specific nutrients, then nutrient densities in the dry matter determine the amount of that nutrient that can be taken in by the animal in the accommodated dry matter in a unit time, e.g. in a day.

Retention time of ingested food, or ingredient, is a function of the rates of fermentation and digestion and the rate of passage of digesta along the gastro-intestinal tract. Faster fermentation/digestion and passage results in less retention time which enhances the refilling of the physical space; consequently total food intake capacity will increase, and *vis a versa*.

IMPLICATIONS

The results presented herein clearly demonstrate that local sheep fed *ad lib* good quality legume, *Trifolium alexandrinum* (Berseem) hay, as the sole diet during breeding and early pregnancy were able to acquire energy commensurate with their requirements as compared to the NRC recommended allowances. Some wastage of protein was observed because of the high protein content of the hay. They were also capable of acquiring their requirements during late pregnancy and lactation when offered free-choice corn grains and cottonseed meal in addition to the hay.

The straw-fed groups, with limited hay or with the molasses-urea mixture, and following the same feeding regime, failed to acquire their requirements when fed the roughage alone during breeding and early pregnancy.

Hay-fed ewes were able to select diets practically optimized for R% and CF% in total dry matter intake, and DIP% in total dietary protein, compatible with the normal functioning of the rumen and its microbes and the metabolic needs of the host animal. The straw-fed ewes failed. Their excessive grain intake might have adversely affected the rumen environment and the metabolism of the host as well.

It is safe to conclude that the all-hay fed ewes were capable of regulating their voluntary food intake through physiological means controlling energy (and protein) intake according to requirements, and preserving the rumen environment as well. On the other hand, those fed straw with its lower rates of digestion and passage and longer retention, in addition to lower nutrient densities, their voluntary food intake was predominantly regulated by physical means related to the fill capacity of the GIT modified by the adverse effects of excessive grain intake on the rumen environment.

These findings, in addition to factors affecting the food intake capacity, are of utmost importance when attempting to devise a feeding management system for housed sheep, intensive or extensive, or a supplementary feeding system for grazing sheep, compatible with the expression of the animal's inherent productive capacity and the economics of production.

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تأثير الرعاية الغذائية على إنتاج الأغنام فى جنوب سيناء :١- إختيار الغذاء وكمية الغذاء المأكول في النعاج .

محمد فريد عبدالخالق فريد ، حجازى سالم خميس ، إيهاب يحيى أحمد عيد ، أحمد هلال.
قسم تغذية الحيوان ، مركز بحوث الصحراء ، المطرية ، القاهرة .

أجريت هذه التجربة لدراسة الصفات الانتاجية والتناسلية للأغنام فى جنوب سيناء ، ولتقنين النظم الغذائية لها . ولعدم توفر المعرفة الكافية بالاحتياجات الغذائية لهذه الأغنام كان من الضروري دراسة إختيار الغذاء والقدرة على إستيعاب الغذاء خلال المراحل المختلفة من دورة الإنتاج .

استخدمت فى الدراسة ٨٥ نعجة موزعة عشوائيا على أربع مجموعات والتى بدورها وزعت عشوائيا على أربع مجموعات تجريبية . مجموعة المقارنة كانت تعطى علائق محسوبة طبقا للمقننات الغذائية الأمريكية طوال فترة التجربة . المجموعات الثلاث الباقية أعطيت أعلاف خشنه متنوعة: دريس البرسيم المصرى ، ثلث دريس وقش أرز ، قش أرز مضافا إليه مركب المفيد بنسبه ١٠% (مركب تجارى يحتوى على ٤٥% يوريا و ٢٢% أملاح معدنية وعناصر نادرة) . كانت التغذية على الأعلاف الخشنة تغذيه حرة ، وقد استخدمت الأعلاف الخشنة بمفردها خلال موسم التلقيح والمرحلة الأولى من الحمل . فى خلال موسم التلقيح أعطيت النعاج فى كل المجموعات مخلوطا مركزا للدفع الغذائى بمعدل ٢٠٠ جرام فى اليوم للنعجة الواحدة . مع بدء المرحلة الثانية من الحمل وحتى نهاية التجربة عند فطام الحوالى بعمر ١٦ أسبوع أعطيت النعاج فى المجموعات الثلاث حبوب الذرة المجروشة وكسب القطن ، تغذية حرة فى معالف منفصلة لقياس إختيار الغذاء والكمية المأكولة . كمية الغذاء المأكولة كانت تقدر يوميا على مدار التجربة والحيوانات كانت توزن كل أسبوعين .

النعاج التى تمت تغذيتها على دريس البرسيم كانت قادرة على اختيار علقية توفر لها إحتياجاتها من الطاقة والبروتين خلال كل مراحل دورة الإنتاج ، والصفات الطبيعية للعليقة المختارة من حيث نسبة العلف الخشن والألياف والجزء من البروتين القابل للهضم فى الكرش كانت كلها فى حدود المتطلبات القياسية في العلائق المتزنة . على ما يبدو فإن تلك النعاج كانت قادرة على التحكم فى كمية الغذاء والعناصر الغذائية المأكولة بواسطة نظم فسيولوجية وهرمونية تحددها إحتياجات الحيوان للطاقة ولا يحد منها قدرة الحيوان على إستيعاب الغذاء .

النعاج فى المجموعتين اللتين كانتا تعطيان قش الأرز ، مع الدريس او مع مركب المفيد ، لم تكن قادرة على التحكم فى كمية الغذاء المأكول حسب احتياجاتها من الطاقة ، وبصفه خاصة خلال الفترة الأولى من الحمل حيث إقتصرت التغذية فقط على الأعلاف الخشنة ، أو خلال فترة الحليب نتيجة للزيادة الكبيرة فى الاحتياجات ، وعلى ما يبدو فإن التحكم فى كمية الغذاء المأكول فى تلك الحيوانات كان يتم من خلال محددات طبيعية أهمها قدرة الكرش والجهاز الهضمى على إستيعاب الغذاء ، ومعدلات الهضم ومرور الكتلة الغذائية . كل ذلك رغم الزيادة الكبيرة فى إستهلاك المواد المركزة خلال فترة الإدرار مما أدى إلى تدنى نسبة العلف الخشن فى العليقة وكذلك نسبة الألياف الخام إلى مادون المتطلبات القياسية في العلائق القياسية المتزنة واللازمة للحفاظ على إتزان البيئة الفسيولوجية فى الكرش ، درجة الحموضة والضغط الأسموزي ، ونمو ونشاط الكائنات الحية الدقيقه فيه .

النتائج المتحصل عليها من هذه الدراسة يمكن الاستفادة بها فى وضع أسس تكوين العلائق المناسبة للمراحل الإنتاجية المختلفة فى النعاج ، والتى تضمن حصولها على إحتياجاتها من الطاقة والبروتين والعناصر الغذائية الأخرى ضمن الكمية من الغذاء التى يمكن للحيوان إستيعابها ، وبالخواص الطبيعية التى تحقق المتطلبات القياسية للعلائق المتزنة ، وهذه كلها يمكن للقارئ إستنباطها من البيانات المعروضة بسيوله ويسر .