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EFFECT OF CONCENTRATE LEVEL ON FERMENTATION IN THE RUMEN AND PERFORMANCE OF SHEEP IN THE NORTHWESTERN COAST OF EGYPT

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ABSTRACT

Sixty growing lambs (30 of which were Rahmani and 30 were Ossimi) were randomly divided into four groups (15 from each breed). Two concentrate levels (2.5 and 3.0% of body weight) were evaluated, while roughage was offered free choice for animals. Concentrate was the traditional concentrate feed mixture (CFM) of which 80% was yellow corn grains and had 77% TDN. The experiment was conducted in the north western coast of Egypt.

Results revealed that increasing concentrate level (3% CFM) increased digestion coefficients of most nutrients and feeding values of the rations. Retained nitrogen also improved and blood total proteins albumin, globulin as well. Average daily gain increased as well as feed efficiency. There were no significant differences in rumen pH and total volatile fatty acids. Cost of producing the unit of growth (Kg) and economic efficiency were in favor of low concentrate level (2.5%). The breed effect was not significant.

Generally, increasing the corn grains in the concentrate feed mixture led to increasing TDN value of the diets. However, the wider roughage to concentrate ratio represented by the 2.5% concentrate level is better than the other ratio for decreasing the cost of producing the unit of body weight gain. The pH values tended to decrease as the concentrate level increased, on the other hand the concentrations of TVFA's showed the opposite trend.

Keywords: roughage: concentrate ratio, rumen, fermentation, corn grains, digestibility, lambs

INTRODUCTION

Several studies showed that many factors affect the extent to which dietary nutrients are digested. One of these factors is the roughage to concentrate ratio. Concentrate feeding to ruminants often decreases the extent of digestion of cell wall constituents due to suppressed growth of cellulolytic bacteria (Bourquin et all 1994). On the other hand, decreasing roughage to concentrate ratio resulted in decreased whole tract digestibility (Ben Ghedalia and Miron 1984). Ead (1999) demonstrated that varying roughage to concentrate ratios had significantly influenced fermentation pattern of the rumen. The inclusion of roughage in ruminant rations is necessary for normal function of the rumen. Consequently, the utilization of diets by ruminants appears to be affected by roughage to concentrate ratio (Owens et al, 1998). Moreover, negative associative effects are experienced by animals when digestibility of rations is less than that of the sum of the individual component feeds (Mould et al, 1983). When concentrates are fed, there is a competition between the digestion and the passage of the potentially digestible fiber may represent a constraint on fiber digestion (McDonnell et al, 1979).

Attia-Ismail *et al.* (1994) found that rice straw is of high feeding value among other roughages. However, one of the most common practices on farms is to let animals consume roughage ad lib with the supplementation of concentrates in restricted amounts of concentrate to be offered to animals thereafter.

This study was conducted to evaluate the effect of feeding two levels of roughage (rice straw) fed ad lib with two different levels of concentrates as two different roughage to concentrate on roughage intake and feeding values of the consumed rations and some fermentation parameters in the rumen.

MATERIALS AND METHODS

Animals and management

The experiment was carried out with 30 Rahmani lambs and 30 Ossimi lambs (18.92 ± 0.153 Kg average body weight) at the Agro- Industrial Compound, Horticulture Services Unit, Agriculture Research Center, North of Egypt. Animals of each breed were divided into two balanced groups each of fifteen animals. The two groups of each breed were assigned at random to receive either 2.5 or 3% CFM of their body weight. The CFM allowances were offered on two portions per day. Rice straw was used as a roughage and was offered ad lib. The residues from rice straw were daily weighed to calculate feed intakes. Water was always available to animals. The feeding trial lasted for 112 days. Live body weight and feed intake were recorded at weekly intervals. After the eighth week of the beginning of the experiment, three animals from each group were assigned randomly to metabolic cages. Feces and urine were collected during the collection week. Blood samples were withdrawn from the Jugular veins of animals before morning diet. Rumen fluid samples were collected at the end of the digestibility trials at zero, 3, and 6 hrs post feeding by stomach tube. Samples were strained through two layers of cheesecloth and immediately used to determine ruminal pH using a battery operated pH meter. The stained samples were immediately frozen at -20°C for later analysis.

Experimental rations

Experimental rations were formulated as follows:

- G1: 15 Rahmani lambs fed concentrate feed mixture (CFM) at 2.5% of BW and rice straw *ad lib*
- G2: 15 Rahmani lambs fed concentrate feed mixture (CFM) at 3% of BW and rice straw *ad lib*
- G3: 15 Ossimi lambs fed concentrate feed mixture (CFM) at 2.5% of BW and rice straw *ad lib*
- G4: 15 Ossimi lambs fed concentrate feed mixture (CFM) at 3% of BW and rice straw *ad lib*

Chemical analysis

Samples of feeds (Table 1), feces, and urine were analyzed according to A.O.A.C., (1990). Serum total protein was determined by the method of Armstrong and Carr, (1964), and albumin (Drupt, 1974). Globulin was estimated by difference. Determination of total volatile fatty acids in rumen liquor was carried out according to Warner, (1964).

Table 1: Chemical composition of tested ingredients of the experimental diets consumed by sheep

Item	DM	OM	CP	CF	EE	NFE	Ash
	DM basis, %						
CFM	89.18	95.25	14.02	3.14	3.03	75.06	4.75
Rice straw	88.23	84.45	4.13	34.12	1.32	44.88	15.55
Calculated rations							
Ration 1	88.89	90.80	9.94	15.91	2.33	62.62	9.20
Ration 2	88.98	91.40	10.49	14.19	2.42	64.30	8.60
Ration 3	88.81	90.71	9.87	16.16	2.31	62.37	9.29
Ration 4	88.92	91.30	10.41	14.46	2.41	64.02	8.70

CFM composed of 80%yellow corn, 15% linseed meal, 3% molasses, 1.5% limestone and 0.5% salt (calculated TDN = 77%)

Statistical analysis

The data were statistically analyzed according to 2X2 factorial design (two breeds and two levels of concentrates). Live body weight and feed intake were analyzed according to repeat measurement design. The General Linear Model Procedures of SAS (1990) package was employed for that purpose.

RESULTS AND DISCUSSION

The results presented in Table (2) indicated that increasing concentrate level from 2.5% to 3% decreased the portion of roughage consumed. Animals consume the concentrate portion of the diet preferentially. However, the amount of concentrate portion in the diet was restricted even when it was increased. The increment in concentrate portion was to get the amount of roughage consumed varied.

However, the increase in concentrate level and hence, the decrease of roughage portion resulted in significant increases in nutrient digestibility coefficients of most nutrients. Dry matter digestibility increased significantly ($P<0.05$) from 62.71 to 66.70% for 2.5 to 3% concentrate levels, respectively. Organic matter also showed better significant digestibility (Table 2). Crude protein, EE, and NFE digestibility coefficients increased significantly as well. The increments of these nutrients ranged from 4% to 5%. The only non significant increased digestibility was that of crude fiber. The increment did not reach 1% which means no variability in fiber digestion. The increased concentrate portion in diets of ruminants usually leads to decreased crude fiber digestibility. The depression in fiber digestibility is usually accompanied by a depression in ruminal pH (Mould et al, 1983). In the present study no depression in fiber digestibility was found. As it will be seen later, the pH of rumen fluid did not change very much (Table 4) to allow for significant reduction in cellulolytic bacteria activity. The differences in the amount of concentrate offered to animals were not large enough to permit for such effect to appear. Miller and Muntifering (1985) explained that the decrease in fiber digestion as a result of increased concentrates may be mediated primarily through the decrease of potential extent of fiber digestion. However, it seems that this result, in additions to the above mentioned explanations, may be due to the absence of lag time for fiber digestion. Miller and Muntifering (1985) increased concentrate portion of diets (corn grains) from 0 to 80% and found no differences in lag time, yet the digestion rate of fiber differed among treatments. They found that there was a lack of linear relationship between potential extent of fiber digestion and starch addition. Interestingly, the digestion rate in their study increased from 0.039 to 0.053 Kd, h^{-1}, the potential extent of fiber digestion did not differ (54.8 to 48.8% ± 6.6) and apparent extent of digestion of fiber digestibility (25.1 to 25.3%) when corn grains level was increased from 20 to 40%, respectively. The result of our study may have fallen in this zone. Other investigators, however, obtained similar results (El-Badawy et al, 2001) of increased crude fiber digestibility when concentrate portion of the ration increased. They linked that to the increased total number of microflora and higher cellulolytic activity in the rumen.

Table 2: Feed intake and digestibility and feeding values of rations as influenced by concentrate level

Item	Level of concentrate		Breed		
	2.5%	**3%**	**Ossimi**	**Rahmani**	**±SE**
Feed intake, g/h/d					
Roughage	511.01	650.52	587.12	574.41	50.351
Concentrates	216.02	201.41	202.11	215.32	26.716
TDMI	727.03	851.93	789.23	789.73	112.813
Digestibility coefficients, %					
DM	62.71^b	66.70^a	64.69	64.71	0.624
OM	66.49^b	71.16^a	68.79	68.86	0.737
CP	64.92^b	69.93^a	67.31	67.54	1.001
CF	51.78	52.49	51.90	52.37	0.250
EE	69.37^b	72.47^a	70.75	71.09	0.543
NFE	70.54^b	75.49^a	73.13	72.91	0.792
Feed value, %					
TDN	62.44^b	67.16^a	64.76	64.85	0.736
DCP	6.43^b	7.30^a	6.82	6.91	0.134

a, and b: means within row for each category bearing different letters differ significantly ($P<0.05$)

Because of increased nutrient digestibility coefficients when concentrate level increased from 2.5% to 3%, the TDN value improved from 62.44% to 67.16%, respectively (Table 2), and so did DCP. However, no significant differences were detected between the two breeds.

Nitrogen metabolism as influenced by concentrate to roughage ratio is presented in Table (3). Nitrogen intake did not vary significantly neither due to varying level of concentrate to roughage ratio nor to breed of sheep. Fecal and urinary nitrogen excretion values were similar. Bourquin et al, (1994) indicated that total nitrogen flow past the duodenum did not differ when varying level of concentrate to roughage ratio (60 versus 96% forage level). They concluded that the incorporation of recycled nitrogen into microbial protein was extensive. They also found that apparent total tract nitrogen digestibility was not affected by forage level. In the present study, apparently digested nitrogen was significantly higher for 3% concentrate level, yet did not differ between the two breeds of sheep and so was true digestibility (digested nitrogen as a percent of nitrogen intake). Nitrogen balance was also higher for the 3% concentrate level, yet did not differ because of breed effect (Table 3). On the other hand, nitrogen balance as a percent of nitrogen intake was significantly higher for the 2.5% concentrate level, and so was nitrogen balance as a percent of digested nitrogen. Mehrez et al, (2001) noted that nitrogen intake differed significantly with varying concentrate to roughage ratio. El-Ayek et al, (2001) reported no difference in total crude protein intake because of varying concentrate to roughage ratio. The differences that existed between the present study (Table 3) and other studies (e.g. Mehrez et al, 2001 and Bourquin et al, 1994) may due in part to that, they used different and wide concentrate to roughage ratio.

Table 3: Nitrogen metabolism as influenced by concentrate level

Item	Level of concentrate			Breed		±SE
	2.5%	3%	±SE	Ossimi	Rahmani	
NI, g/h/d	18.96	24.15	2.842	21.77	21.34	2.147
N excretion, g/h/d						
Fecal	6.65	7.29	1.238	7.08	6.86	0.989
Urinary	5.21	9.21	0.982	7.39	7.03	1.057
N utilization, g/h/d						
N digested	12.31^{b}	16.86^{a}	2.358	14.69	14.48	1.543
N balance	7.10^{b}	7.65^{a}	0.325	7.30	7.45	0.871
ND, % of NI	64.93^{b}	69.81^{a}		68.72	67.85	
NB, % of ND	57.68^{a}	45.37^{b}		49.69	51.45	
NB, % of NI	37.45^{a}	31.68^{b}		33.53	34.91	

a, and b: means within row for each category bearing different letters differ significantly ($P<0.05$)

Table (4) shows the values of rumen and blood parameters as influenced by concentrate level. No significant differences were found due to the level of concentrate or to breed of sheep. Yet, the apparent pH values were lower at 3% concentrate level than at 2.5% concentrate level for corresponding increases in TVFA's concentrations. Average values of pH at breed level were almost identical (6.42 and 6.43 for Ossimi and Rahmani, respectively). The trend of pH after feeding was a typical one (Gabr et al, 2001) and coincided with the rise in TVFA's concentrations when animals were fed the concentrates. Briggs et al, (1957) indicated that the rise in volatile fatty acid concentration causes a reduction in pH values. However, concentrations of TVFA's (meq%) did not differ significantly as a result of increasing concentrate level in rations; although they were higher for the higher concentrate level (5.78 and 5.92 meq% for 2.5% and 3% levels, respectively). Since the difference between the two concentrate levels was not great, the differences in pH values and TVFA's concentrations were not significant either. However, no differences between breeds were expected in that respect. Mehrez et al, (2001) found that the increase in CFM in rations caused an increase in TVFA's concentrations. These effects are probably due to better utilization of dietary carbohydrates (Fadel et al, 1987). This stimulation of rumen function can be beneficial in providing more energy for microbial growth and more protein synthesis. Conclusively, it appears, under the well-controlled experimental conditions of the present study, that the *rumen function was not altered in way that may cause a reduction in animal* performance.

Table 4: Rumen and blood parameters as influenced by concentrate level

Item	Time	Level of concentrate		Breed		±SE
		2.5%	3%	Ossimi	Rahmani	
PH						
	0	6.77	6.75	6.77	6.77	0.014
	3	6.23	6.18	6.21	6.20	0.014
	6	6.34	6.28	6.31	6.31	0.018
	Ave	6.45	6.41	6.42	6.43	0.012
TVFA's, meq/100ml						
	0	4.34	4.37	4.41	4.30	0.071
	3	6.71	6.91	6.79	6.82	0.052
	6	6.30	6.49	6.41	6.38	0.072
	Ave	5.78	5.92	5.87	5.83	
Serum						
TP		6.75^{b}	7.33^{a}	7.00	7.08	0.094
AL		4.28^{b}	4.68^{a}	4.44	7.52	0.070
GL		2.47^{b}	2.65^{a}	2.56	2.56	0.034

a, and b: means within row for each category bearing different letters differ significantly (P<0.05)

Serum total protein concentrations differed significantly (P<0.05). It was higher for the 3% concentrate level. This can be linked to the higher nitrogen digestibility and balance at the same concentrate level (Table 3). Consequently, albumin and globulin concentrations followed the same trend. Solouma, (1999) found that increasing protein level in the diet for lambs resulted in increased blood total protein and its fractions. Chandler et al, (1968) reported that a positive correlation exists between dietary protein intake and blood protein concentrations. However, the increase in serum proteins in the present study may be attributed to increased nitrogen balance (Table 3).

Animal performance is presented in Table (5). The changes in average body weight did not differ due to the effect of concentrate level or to the animal breed effect. Yet, average of relative growth rate was higher (105 and 113 for 2.5% and 3% concentrate levels, respectively) significantly (P<0.05) and so was average daily gain (177.10 and 190.71 g/h/d for 2.5% and 3% concentrate levels, respectively). The higher average daily gains reported in the present study than those of other investigators (84-97 g/h/d) reported by Deraz and Mohamed, (1999), (100-110 g/h/d) reported by Mohamed et aql, (2000), (100–150 g/h/d) reported by Salem and El-Mahdy, 2001 for Ossimi lambs) and (92-118 g/h/d) of El-Hosseiny et al, 1997, 96-118 g/h/d reported by Mohamed and Diaa El-Din, 2000 for Rahmani lambs) may be a direct reflection of increased grains in the CFM (80% yellow corn grains and 77% TDN, Table 1). Shehata and El-Sayed, (1994) and Shalaby, (2000) reported that increasing corn grains in rations increased average daily gain. The better digestion coefficients that were noticed in the present study was expected due to the higher proportion of yellow con in CFM (80%). Yellow corn grains present a source of available carbohydrates for rumen microflora. The greater the availability of starch for rumen microorganisms (Oliveria et al, 1995), the greater the microbial protein synthesis (Overton et al, 1995). This has implications on daily gain (Chen et al, 1994).

Daily dry matter intakes of different ingredients are present in Table (5). Dry matter intake from CFM increased significantly (P<0.05) as the level of concentrates increased (750.14 and 611.8 for 3 and 2.5% levels respectively). Intake from rice straw followed the reverse trend of concentrates, yet not significantly. Mehrez et al, (1993) found that when CFM level increased in rations, the DM intake from roughage decreased. Total dry matter intake was significantly different and increased as the level of concentrates increased. The same trend was observed with TDN intake and DCP intake.

Feed efficiency measured as Kg DM, TDN, or DCP/Kg gain were significantly (P<0.05) different for the two concentrate to roughage ratios but not between the two breeds of sheep. The improvement in feed efficiency with the 2.5% concentrate level might be attributed to the increased efficiency of nutrient absorption. Cost per Kg of gain was not different either; although it was higher for the higher concentrate level. The economic efficiency was better for the lower level of concentrates.

Generally, increasing the concentrate feed mixture led to increased TDN value of the diets. However, the lower concentrate level (2.5%) containing ration is better than that of the higher level in decreasing the cost of producing the unit of body weight gain. Additionally, it represented higher economic efficiency. On the other hand, the higher concentrate level (3%) is better if the period of fattening is of concern. Also, it increased the nutrient digestibility coefficients except for the fiber portion of the rations. However, pH values tended to decrease as the concentrate level increases, on the other hand the concentrations of TVFA's showed the opposite trend.

Table (5): Animal performance as influenced by concentrate level

Item	Level of concentrate		Breed		±SE
	2.5%	3%	Ossimi	Rahmani	
No of animals	30	30	30	30	
Initial BW, Kg	18.935	18.90	18.87	18.97	0.153
Final BW, Kg	38.770	40.26	39.21	39.83	
BW change, Kg	19.835	21.36	20.34	20.86	
Relative GR	105[b]	113[a]	108	110	1.870
Daily gain, g	177.10[b]	190.71[a]	181.56	186.25	
Daily DMI, g/h/d					
CFM	611.8[b]	750.14[a]	687.38	674.56	45.94
Rice straw	315.11	307.49	316.42	306.18	12.63
TDMI	926.91[b]	1057.63[a]	1003.8	988.74	52.36
TDN intake	578.77[b]	710.32[a]	636.64	652.44	37.26
DCP intake	59.61[b]	77.21[a]	67.17	69.65	4.28
Feed efficiency					
Kg DM/Kg gain	5.24[b]	5.55[a]	5.40	5.39	
Kg TDN/Kg gain	3.27[b]	3.73[a]	3.50	3.50	
Kg DCP/Kg gain	0.34[b]	0.41[a]	0.37	0.38	
Cost/Kg gain*	4.20	4.74	4.48	4.46	
Economic efficiency**	3.41	3.02	3.20	3.22	

a, and b: means within row for each category bearing different letters differ significantly ($P<0.05$)
*** based on the assumption that the prices of one ton of CFM and rice straw are 727 and 60 LE, respectively, the price of one Kg live body weight gain was 10.00 LE**
**** the ratio between the price of the weight gain and cost of feed consumed**

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تأثير مستوى العلف المركز على بعض خصائص التخمر فى الكرش واداء الاغنام في الساحل الشمالى الغربى بمصر

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** مركز بحوث الصحراء – وزارة الزراعة – المطرية

تم استخدام ستون حمل منها ثلاثون اوسيمى وثلاثون رحمانى وقسمت الى اربعة مجاميع متساوية (١٥ حمل لكل) لتقييم التغذية على العلف المركز المرتفع فى نسبة المركبات الكلية المهضومة (٧٧%) وذلك وفقا لنسبته من وزن الجسم ٢,٥% و ٣% مع استخدام قش الارز كتغذية مفتوحة وذلك لعمل نسبتين مختلفتين من العلف الخشن الى المركز واجريت هذه الدراسة فى منطقة الساحل الشمالى الغربى بمصر

اوضحت النتائج انه بزيادة نسبة العلف بالعليقة ترتفع معنويا معاملات الهضم والقيم الغذائية والنيتروجين المحتجز وبروتين الدم ومعدل النمو اليومى والكفاءة التحويلية للغذاء لانتاج كيلو النمو وتاثرت قياسات الاس الهيدروجينى والاحماض الاحماض الدهنية الطيارة ولكن بشكل غير معنوى

وتلاحظ انه فى المستوى الاقل فى نسبة العلف المركز (٢,٥%) انخفضت تكلفة انتاج كيلو النمو كما تلاحظ بصفة عامة انه لا توجد فروق معنوية بين نوعى الحملان وانه يمكنها التاقلم فى تلك المناطق تحت ظروف رعاية وتغذية جيدة