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Influence of Supplementing Different Soybean Meal (Urea Ratios with Different Poor Quality Roughage-basal Diets) on Digestion and Fermentation in the Rumen of Sheep

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Abstract: Three mature male ruminally cannulated sheep were fed on 90% of their *ad libitum* intake during successive metabolism trials. The results showed that N-balance (g/day), TDN% and DCP% were significantly higher when RS ration was supplemented with 2.5% SBM + 1.5% U than that supplemented with 7.5% SBM + 0.5% U. DCP% and N-balance were significantly lower when MS ration supplemented with 2.5% SBM + 1.5% U than other supplements, but digestibility of NFE, cellulose, TDN% of the ratio of NFC intake to DCP intake were significantly higher with (7.5% SBM + 0.5% U) or (2.5% SBM + 1.5% U) than (5% SBM + 1% U) supplementation. Feeding MS rations resulted in increasing ($P<0.01$) NFE digestibility and TDN% when supplemented with (7.5% SBM + 0.5% U) or (2.5% SBM + 1.5% U), while the digestibilities of CF, ADF and cellulose decreased when MS ration was supplemented with (5% SBM + 1% U). Moreover, a positive and highly significant correlation coefficient ($r=0.610$, $n=18$;) was obtained between NFC and DCP intake. The *In situ* DM, NDF and ADF disappearance values of MS were higher than those of RS, while the DM disappearance of MS was higher when MS ration was supplemented with (5% SBM + 1% U) than the other supplements. The potential degradability (a+b) of ADF of RS was higher when RS ration was supplemented with (7.5 SBM + 0.5%U) or (2.5% SBM + 1.5% U) than that of 5% SBM + 1.0% U) being 58.47, 54.86 and 41.59%, respectively. The potential degradability (a+b) of ADF of MS was higher when MS ration was supplemented with (2.5% SBM + 1.5% U) than that of (5% SBM + 1.0% U) or (7.5% SBM + 0.5% U), being 63.83, 51.14 and 49.77, respectively. The mean rumen pH was decreased when MS ration was supplemented with (5% SBM + 1% U) than those of the other rations. While NH_3-N concentration decreased when MS ration was supplemented with (7.5% SBM + 0.5% U) or (5% SBM + 1% U) and when RS ration was supplemented with (7.5% SBM + 0.5% U). The total volatile fatty acids (VFA) concentration was higher for supplemented MS rations than that of RS rations, while it was decreased when MS ration was supplemented with (2.5% SBM + 1.5% U) than that of (7.5% SBM + 0.5% U) or (5% SBM + 1% U).

Key words: Sheep, rice straw, maize stalks, *In sacco* evaluation.

Introduction

Identification of cell wall characteristics that should be targets of genetic modification is required if plant breeders and molecular biologists are to successfully improve forages for livestock feeding. As the forage plant cell develops, phenolic acids and lignin are deposited in the maturing cell wall in specific structural conformations. Lignin is the key element that limits cell wall digestibility (Jung and Allen, 1995). In addition, Hoover and Miller (1991) reported that optimum feed utilization by ruminants is dependent on achieving maximum rumen fermentation and flow of microbial protein to the duodenum. It is clear that the major nutrients required by the microbial population include both fibrous and non fibrous sources of carbohydrates and nitrogen in the form of ammonia, amino acids and peptides. The exact quantities and sources of these nutrients that will achieve optimum rumen fermentation rates and microbial yields are only partially known. Such information are badly needed for maximizing the feed utilization and ruminants productivity.

Thomas (1998) reported that over the next 30 years, population will grow to a level that will demand an increase of two or three times the present levels of production of food. Over the same period very little new land can be brought. So, the evaluation and feeding of by-products has been an essential part of animal nutrition and feed manufacturing.

The main objective of this investigation, therefore, was to study the influence of supplementing different soybean: urea ratio to different poor quality roughage-basal diets on digestion and fermentation in the rumen of sheep.

Materials and Methods

The experimental work was conducted at Agricultural Experimental Station, and the laboratories of Animal Production Department, Faculty of Agriculture, Mansoura University.

Experimental design: Six experimental rations (Table 1a) were formulated to investigate the influence of supplementing two tested roughage (rice straw or maize stalks) with different combinations of CFM (traditional supplement), SBM (good source of amino acids) and urea on digestion and fermentation in the rumen of sheep. The experimental rations were formulated to be almost iso-nitrogenous and to contain slightly more than 12% crude protein recommended by Ørskov (1972) to ensure maximal rate of fermentation in the rumen.

Table 1a: The formulation of the experimental rations

Ingred.	Formulation rations					
	1	2	3	4	5	6
RS	60.0	60.0	60.0	-	-	-
MS	-	-	-	60.0	60.0	60.0
CFM*	32.0	34.0	36.0	32.0	34.0	36.0
SBM**	7.5	5.0	2.5	7.5	5.0	2.5
U***	0.5	1.0	1.5	0.5	1.0	1.5

* Concentrate feed mixture, ** Soybean meal
*** Urea

The rice straw and maize stalks were chopped to a length of 5 cm. The CFM contained about 15.81% CP.

Experimental animals and their management: Six digestibility and metabolism trials were carried out on sheep. Three healthy Rahmany rams were used. They were about 1.5 – 2.0 years old, with an average live body weight of 45 Kg. They were fitted with wide permanent rumen cannula (4 cm diameter).

Each experimental diet was offered *ad lib.* at 8.00 am to the animals.
Faeces and urine were collected separately and quantitatively for 7 days. Ruminal studies were carried out during the following 7 days.
The same three cannulated sheep were used for studying some rumen fluid parameters at different intervals after feeding and for determining the rate of DM and CF fractions disappearance in the rumen using artificial fiber bag technique (Mehrez and Ørskov, 1977). These measurements were repeated twice during each experimental period after the digestion trials.
Rumen fluid samples were collected through the cannula from different locations in the rumen. On each of the two sampling days, rumen fluid was collected just before offering the morning feed and at 2, 4 and 8 hrs post-morning feeding. The samples were filtered through two layers of surgical gauze and were used for determining pH, total volatile fatty acids (VFA), and ammonia-N concentrations.

Chemical analysis: The chemical analysis of tested materials, faeces and urinary nitrogen were determined according to the official methods of the A.O.A.C. (1984). The NDF, ADF and ADL were determined by the methods of Goering and VanSoest (1970). While, cellulose and hemicellulose were accordingly calculated.

***In situ* disappearance:** The artificial fiber bag technique of Mehrez and Ørskov (1977) was applied for measuring rate of DM disappearance in the rumen. On each of the sampling days, 6 weighed dacron bags were incubated in the rumen of each sheep (8, 16, 24, 36, 48 and 72 hrs incubation interval). Each bag contained about 3 grams DM of the tested roughage (RS or MS) with their corresponding experimental ration. The data of disappearance were fitted by the exponential equation derived by Ørskov and McDonald (1979) to describe the relation between disappearance and elapse of time of incubation and to predict the degradable potential of the tested materials. In order to define and divide the portions of material which disappear from the bags during incubation in the rumen into, they described the relationship between disappearance and elapse of time of incubation through an exponential equation:

$$P = a + b\,(1-e^{-ct})$$

"P" represents the percentage degradability at time t.
"a+b" represents the fermentable part of the material.
"c" represents the un degradable fraction.
"t" time (hr)

Rumen liquor (RL) pH was estimated using pH meter while the total VFA were determined by the method of Abou Akkada and El-Shazly (1964). The concentration of ammonia-N was determined by the method of Conway and O'Malley (1942).

Statistical analysis: The data collected for each parameter was analyzed by factorial design in order to ascertain whether the observed treatment effects were real and discernible from chance effects. The null hypothesis was tested by F-test of significance (Gomez and Gomez, 1984). The differences between treatment means were tested by Duncan's Multiple Range Test (Duncan, 1955).

Results

The chemical composition of rice straw, maize stalks, concentrate feed mixture, soybean and urea are detailed in Table 1a and b. The chemical composition of the total mixed rations is detailed in Table (2).
The more OM content of MS was mainly in NFE and NFC contents. However, MS contained less CF, ADF, cellulose and ADL than RS. Such differences were reflected on the nutrient contents of the corresponding experimental rations.

Table 1b: The chemical composition of the ingredients used to formulate the experimental rations*.

Items	RS	MS	CFM	SBM
DM %	91.93	90.81	88.90	89.17
Composition of DM %:				
OM	83.68	92.52	90.16	92.66
CP	4.89	4.33	15.81	52.68
EE	1.70	2.02	2.35	2.51
CF	36.30	32.86	11.37	3.45
NFE	41.07	53.31	60.53	34.02
Ash	16.32	7.48	9.84	7.34
NDF	74.66	75.01	35.34	28.46
ADF	51.67	45.25	12.79	3.31
Hemicellulose	22.99	29.76	22.55	25.15
Cellulose	38.67	34.64	10.57	1.77
ADL	13.00	10.61	2.22	1.54
NFC**	2.68	11.16	36.66	9.01

* Urea (fertilizer grade contained 44% N).
** Non-fibrous carbohydrates = OM – (CP+NDF+EE). (Calsemiglia *et al.*, 1995).

Effect of experimental diet on digestion coefficients, dry matter intake, N-balance and feeding value of rations: As shown in Table (3), the voluntary DM intake and the digestibilities of all nutrients for RS rations were not affected by treatments. But N-balance (g/day), ME and DCP% were significantly ($P<0.05$) higher when RS ration was supplemented with (2.5% SBM + 1.5% U) than that of (7.5% SBM + 0.5% U). However, the voluntary DM intake, and the digestibilities of DM, EE, NDF, hemicellulose and TDN intakes for MS rations were not affected by treatments. While DCP% and N-balance were significantly ($P<0.01$) lower when MS ration was supplemented with (2.5% SBM + 1.5% U) than that of other supplements. The digestibility coefficients of NFE, cellulose, TDN% and the ratio of NFC intake to DCP intake were decreased significantly ($P<0.01$) with (5% SBM + 1% U) than the other supplements. On the other hand, the digestibility of NFE and TDN% was significantly ($P<0.01$) increased when MS ration was supplemented with (7.5% SBM + 0.5% U) or (2.5% SBM + 1.5% U). While the digestibility of CF and ADF decreased ($P<0.05$) and cellulose also decreased ($P<0.01$) when MS ration was supplemented with (5% SBM + 1% U) than the RS rations. As shown in Fig. 1 the ratio of NFC intake to DCP intake were significantly ($P<0.01$) higher in MS diets than RS diets. The relationship between NFC intake (x) and DCP intake (y) using the pooled data of all treatments was as follows:

$$y = 54.03 + 0.211\,x \quad (r = 0.610^{**},\ n=18)$$

The DCP intake was positively correlated ($P<0.01$) with NFC intake.

Effect of experimental diet on DM, NDF and ADF disappearance in the rumen: Table (4) shows that DMD of MS was higher ($P<0.05$) at 8 hrs when supplemented with (5% SBM + 1% U) or (2.5% SBM + 1.5% U) than those of the other treatments. The DMD of MS was more ($P<0.05$) at 24 hr when supplemented with (5% SBM + 1% U) and was also more () from 36 hr up to 72 hr when MS ration was supplemented with (5% SBM + 1% U) or (2.5% SBM + 1.5% U) than the other treatments.
The NDFD and ADFD of MS followed similar trend as DMD at 8 hr, then there were no significant effect when MS ration

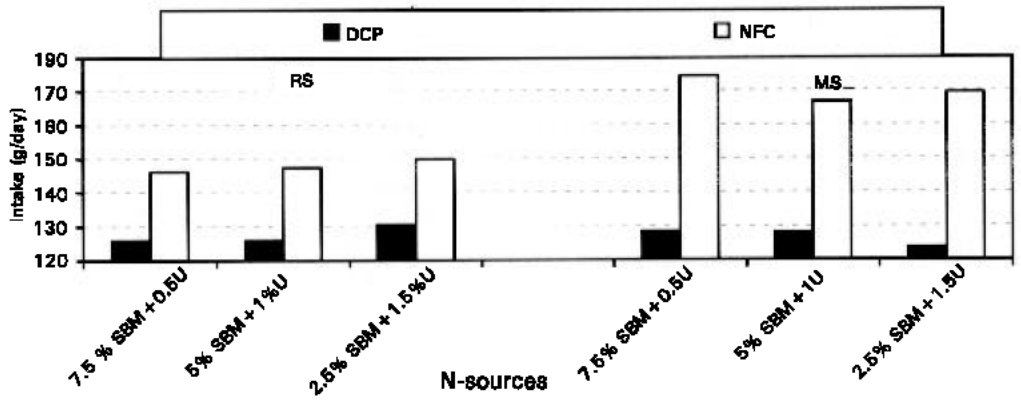

Fig. 1: The relationship betwveen NFC intake (g/day) and DCP intake (g/day).

Table 2: Formulation and the chemical composition of total mixed rations offered to sheep during the trials.

Items	RS			MS		
Formulation (%):	(1)	(2)	(3)	(4)	(5)	(6)
Roughage	60.0	60.0	60.0	60.0	60.0	60.0
FCM	32.0	34.0	36.0	32.0	34.0	36.0
SBM	7.5	5.0	2.5	7.5	5.0	2.5
Urea	0.5	1.0	1.5	0.5	1.0	1.5
Chemical composition (%):						
DM	90.29	89.84	89.39	89.62	89.17	88.72
Composition of DM:						
OM	86.01	85.50	84.98	91.31	90.80	90.29
CP	13.34	13.74	14.14	13.01	13.41	13.81
EE	1.96	1.94	1.93	2.15	2.14	2.12
CF	25.68	25.82	25.96	23.61	23.75	23.90
NFE	46.56	46.92	47.28	53.91	54.27	54.63
Ash	13.49	13.50	13.52	8.19	8.20	8.21
NDF	58.24	58.23	58.23	58.45	58.44	58.44
ADF	35.34	35.52	35.69	31.49	31.66	31.84
Hemicellulose	22.90	22.72	22.54	26.96	26.78	26.60
Cellulose	26.72	26.88	27.05	24.30	24.47	24.63
ADL	8.63	8.63	8.64	7.19	7.20	7.20
NFC	14.01	14.52	15.03	19.10	19.61	20.12

Table 3: Interaction between roughage and N-sources on digestion coefficients, dry matter feed intake, N-balance and feeding value of rations.

Items	RS			MS		
	(1)	(2)	(3)	(4)	(5)	(6)
Nutrient digestibility (%):						
DM	58.23	59.49	60.29	60.93	55.87	64.43
OM	62.79^{c}	62.60^{c}	64.92^{bc}	73.21^{a}	63.41^{c}	68.94^{ab}
CP	70.73^{ABC}	69.37^{BC}	74.02^{AB}	71.58^{ABC}	76.75^{A}	66.79^{C}
EE	77.21	76.40	72.03	83.63	80.85	84.85
CF	64.67^{b}	64.79^{b}	68.82^{ab}	74.04^{a}	62.97^{b}	71.30^{a}
NFE	59.59^{B}	61.17^{B}	63.02^{B}	73.58^{A}	61.66^{B}	70.02^{A}
NDF	57.23	56.91	58.70	56.48	53.37	65.14
ADF	45.12^{a}	46.77^{a}	47.37^{a}	47.42^{a}	38.07^{b}	51.55^{a}
Hemicellulose	76.09	72.81	76.80	72.30	71.55	81.88
Cellulose	58.80^{B}	60.60^{B}	61.45^{B}	61.46^{B}	48.55^{C}	70.26^{A}
ADL	1.68^{BC}	3.67^{AB}	3.34^{AB}	3.99^{A}	2.48^{ABC}	0.66^{C}
NFC	80.86^{B}	85.28^{B}	89.05^{B}	130.13^{A}	88.20^{B}	85.88^{B}
DM feed intake (g/day)	872.0	858	864.0	934.0	835.0	839.0
N-balance (g/day)	5.14^{BC}	6.87^{AB}	8.71^{A}	6.55^{AB}	7.30^{AB}	2.87^{C}
Feeding value as DM%:						
TDN	56.93^{D}	58.37^{CD}	61.35^{BC}	70.60^{A}	62.82^{B}	68.77^{A}
TDN intake (g/day)	499.0	500.0	530.0	659.0	525.0	562.0
ME (MJ/Kg DM)*	7.51^{c}	8.69^{bc}	9.13^{ab}	10.51^{a}	9.35^{ab}	10.24^{a}
DCP	9.44^{C}	9.53^{BC}	10.47^{A}	9.31^{BC}	10.29^{AB}	9.22^{C}
DCP intake (g/day)	82.20	81.77	90.46	86.96	85.92	77.36
NFC intake (g/day)	122.20	124.50	129.80	178.50	163.70	168.80
NFC intake / DCP intake	1.48^{C}	1.53^{C}	1.40^{C}	1.97^{A}	1.86^{B}	2.12^{A}

Values with different capital superscripts in the same row significantly differed at .
Values with different small superscripts in the same row significantly differed at $P < 0.05$.
* ME (MJ/Kg DM) = TDN% x 3.56 x 4.182 (McDonald *et al.*, 1978).

Table 4: Effect N-sources on DM, NDF and ADF disappearance of the tested roughage at different incubation periods.

Period (hr)	RS			MS			LSD	
	(1)	(2)	(3)	(4)	(5)	(6)	P<0.05	
8	19.96^{p}	16.06^{p}	17.31^{p}	18.68^{p}	42.86^{hi}	42.86^{hi}	0.765	4.998
16	27.96^{no}	24.23^{o}	25.35^{o}	29.46^{n}	51.94^{de}	48.31^{efg}		
24	34.16^{Lm}	30.28^{mn}	31.72^{mn}	37.03^{jKL}	56.71^{c}	52.55^{de}		
36	41.01^{ij}	36.56^{KL}	38.53^{jk}	44.38^{ghi}	60.28^{bc}	57.24^{c}		
48	45.79^{fgh}	40.59^{ijk}	43.16^{hi}	48.71^{def}	61.95^{ab}	60.52^{abc}		
72	51.62^{de}	44.86^{fghi}	48.46^{efg}	52.78^{d}	63.22^{ab}	64.49^{a}		
SEM (standard error of means) = 1.336; n = 3.								
NDFD %								
8	21.40^{L}	20.73^{L}	22.06^{L}	19.83^{L}	40.25^{hi}	43.76^{fgh}	4.002	5.312
16	28.16^{K}	28.50^{K}	28.47^{K}	30.77^{jk}	49.81^{de}	50.85^{d}		
24	33.54^{J}	33.73^{J}	33.89^{J}	38.34^{I}	56.00^{c}	55.65^{c}		
36	39.88^{hi}	38.55^{I}	40.50^{ghi}	45.59^{ef}	61.46^{b}	60.22^{b}		
48	44.82^{fg}	41.22^{fghi}	45.70^{ef}	49.82^{de}	64.35^{ab}	62.96^{ab}		
72	52.18^{cd}	43.41^{fgh}	53.08^{cd}	53.79^{cd}	66.67^{a}	65.84^{a}		
SEM (standard error of means) = 1.42; n = 3.								
ADFD %								
8	15.25^{NO}	11.24^{O}	12.79^{O}	9.93^{O}	30.54^{IJ}	37.18^{GH}	3.937	5.225
16	21.88^{LM}	23.27^{KLM}	21.57^{LM}	19.75^{MN}	40.91^{EFG}	42.21^{DEFG}		
24	27.49^{JK}	30.46^{IJ}	28.50^{JK}	27.11^{JKL}	45.93^{CDE}	46.28^{CDE}		
36	34.33^{HI}	36.26^{GH}	36.26^{GH}	34.85^{HI}	49.16^{BC}	50.97^{BC}		
48	39.65^{FGH}	39.01^{GH}	41.71^{DEFG}	39.91^{FGH}	50.35^{BC}	54.39^{AB}		
72	43.03^{CD}	40.97^{EFG}	48.26^{C}	45.42^{CDEF}	50.96^{BC}	57.73^{A}		

SEM (standard error of means) = 1.396; n = 3.
Values with different capital superscripts in the same row significantly differed at .
Values with different small superscripts in the same row significantly differed at P<0.05.

Table 5: Effect of the tested roughage type and N-sources on the DM, NDF and ADF disappearance.

Items	Roughage		N-source		
	RS	MS	7.5% SBM+0.5% U	5% SBM+1% U	2.5% SBM+1.5% U
DM	34.31^{B}	49.67^{A}	37.63^{B}	44.13^{A}	44.21^{A}
NDF	36.10^{B}	50.89^{A}	38.18^{C}	45.39^{B}	46.91^{A}
ADF	30.89^{B}	40.76^{A}	30.22^{C}	37.42^{B}	39.82^{A}

A, B: Values with different superscripts significantly differed at .

Table 6: Effect of N-source supplements on the DM, NDF and ADF disappearance of the tested roughage.

Items	RS			MS		
	(1)	(2)	(3)	(4)	(5)	DM
DMD	36.75^{D}	32.10^{F}	34.09^{E}	38.51^{C}	56.16^{A}	54.33^{B}
NDFD	36.66^{C}	34.36^{D}	37.28^{C}	39.69^{B}	56.43^{E}	56.54^{A}
ADFD	30.94^{CD}	30.20^{CD}	31.52^{C}	29.50^{D}	44.64^{B}	48.13^{A}

A, B: Values with different superscripts significantly differed at .

Table 7: Effect of the tested roughage type and N-sources on the degradability (a+b) of DM, NDF and ADF.

Items	RS			MS		
	(1)	(2)	(3)	(4)	(5)	(6)
DM	58.42^{BC}	48.34^{D}	53.32^{CD}	54.98^{CD}	63.72^{AB}	69.30^{A}
NDF	75.46^{a}	47.88^{b}	67.32^{ab}	56.11^{ab}	67.60^{ab}	65.80^{ab}
ADF	58.47^{AB}	41.59^{D}	54.86^{BC}	49.77^{c}	51.14^{bc}	63.83^{A}

A, B: Values with different superscripts significantly differed at .
a, b, c: Values with different superscripts significantly differed at P<0.05.

Table 8: Effect of the tested roughage type and N-sources on some rumen liquor parameters at different times of sampling.

Items	Period (h)	RS			MS		
		(1)	(2)	(3)	(4)	(5)	(6)
pH	0	7.02	6.67	6.70	6.63	6.47	6.70
	2	6.53	6.23	6.43	6.28	6.02	6.65
	4	6.45	6.15	6.17	6.33	5.82	6.52
	8	6.37	6.20	6.12	6.33	5.80	6.58
Mean	6.59^{A}	6.31^{B}	6.35^{B}	6.40^{B}	6.03^{C}	6.61^{A}	
NH_3	0	15.00	21.93	11.31	18.14	16.84	18.86
	2	23.25	30.00	31.58	24.03	20.70	26.84
	4	16.58	25.26	23.51	19.12	18.51	20.44
	8	15.87	22.63	18.95	17.72	15.53	16.40
Mean	17.67^{C}	24.96^{A}	21.34^{B}	19.75^{BC}	17.90^{C}	20.64^{B}	
VFA	0	7.52	7.47	8.31	6.73	6.74	5.93
	2	8.99	8.97	7.84	7.79	9.04	5.99
	4	10.00	9.73	9.29	8.43	8.63	6.57
	8	10.28	9.40	8.99	8.44	8.40	6.92
Mean	9.20^{A}	8.89^{A}	8.61^{AB}	7.85^{C}	8.20^{BC}	6.35^{D}	

Values in the same row without different superscripts did not significantly differ.
A, B: Values in the same row with different superscripts significantly differed at .

was supplemented with (5% SBM + 1% U) or (2.5% SBM + 1.5% U) from 16 hr up to 72 hr, but the values were significantly ($P<0.01$) higher than the other treatments. The ADFD of MS followed the same trend as NDFD.
The DMD and NDFD of RS decreased ($P<0.05$) at 16 hr when supplemented with 5% SBM + 1% U than other values of other supplements, then DMD and NDF were decreased. The ADFD of RS followed the same trend as NDFD.

Effect of the tested roughage type, and N-sources on the DM, NDF and ADF disappearance: Table (5) shows that the DMD, NDFD and ADFD of MS were higher ($P<0.01$) than those of RS. The effect of N-sources show that the DM disappearance increased ($P<0.01$) with supplemented (5% SBM + 1% U) or (2.5 SBM + 1.5% U) than (7.5% SBM + 0.5% U), but NDF and ADF disappearance increased ($P<0.01$) with increasing U in the supplement.

Effect of N-source supplements on DM, NDF and ADF disappearance of the tested roughage: Table (6) shows that the DM disappearance of RS increased ($P<0.01$) when supplemented with (7.5% SBM + 0.5% U) than the other supplements, while NDFD% decreased ($P<0.01$) when supplemented with (5% SBM + 1% U). The DM disappearance of MS increased ($P<0.01$) when supplemented with (5% SBM + 1% U) than the other supplements, while NDF and ADF disappearance increased ($P<0.01$) with (2.5% SBM + 1.5% U) than the other supplements.

Effect of experimental diet on the degradable (a+b) DM, NDF and ADF of RS and MS in the rumen: As shown in Table (7) the degradable (a+b) DM, NDF and ADF of RS increased ($P<0.01$) when RS ration was supplemented with 7.5% SBM + 0.5% U than 5% SBM + 1% U, but without significant difference with (2.5% SBM + 1.5% U) or (5% SBM + 1% U), except on the degradable (a+b) ADF which decreased ($P<0.01$) with the last one.

Effect of supplemental diet on pH, NH_3-N concentration and total VFA of rumen liquor at different times of sampling: The effect of experimental diets on some rumen liquor parameters are presented in Table (8).

pH: As shown in Table (8), the mean values decreased significantly ($P<0.01$) when RS ration was supplemented with 5% SBM + 1% U or 2.5% SBM + 1.5% U than with (7.5% SBM + 0.5% U), being 6.31, 6.35 and 6.59, respectively. On the other hand, the mean values decreased ($P<0.01$) when MS ration was supplemented with 5% SBM + 1% U than with 7.5% SBM + 0.5% U or 2.5% SBM + 1.5% U, being 6.03, 6.40 and 6.61, respectively. In general, the pre-feeding pH values were the highest with all treatments and tended to decrease gradually up to 8 hrs after feeding.

NH_3-N concentration: Table (8) shows that the mean values of NH_3-N concentration decreased ($P<0.01$) when RS ration was supplemented with 7.5% SBM + 0.5% U than the other treatments, but NH_3-N concentration was more higher ($P<0.01$) with (5% SBM + 1% U) than with (2.5% SBM + 1.5% U). On the other hand, the mean values of NH_3-N concentration decreased ($P<0.01$) when MS ration supplemented with 5% SBM + 1% U than the other treatments. The least NH_3-N concentrations were generally observed before feeding and reached the peak values at 2 hrs post-feeding. The values tended to decrease afterwards to reach almost the pre-feeding values after 4 to 8 hrs post-feeding with all treatments.

Total VFA: Table (8) shows that there was no significant effect between the mean values of RS ration with different treatments. The mean values of the total VFA were significantly ($P<0.01$) higher when MS ration supplemented with (7.5% SBM + 0.5% U) or (5% SBM + 1% U) than with (2.5% SBM + 1.5% U), being 7.85, 8.20 and 6.35 ml eq./100 ml RL, respectively. The VFA concentrations for all treatments were the lowest before feeding and tended to increase generally up to 4 to 8 hrs after feeding.
On the other hand, the degradable (a+b) DM of MS was significantly ($P<0.01$) higher when MS ration was supplemented with 5% SBM + 1% U or 2.5% SBM + 1.5% U, but there were no significant difference of the treatments on the degradable (a+b) of NDF, while the degradable (a+b) ADF increased ($P<0.01$) when MS ration was supplemented with 2.5% SBM + 1.5% U than the other supplements.

Discussion

The summative analysis of the ingredients (Table 1) used to formulate the experimental rations were within the normal published ranges (Ead, 1999; El-Ayouty, 1991; Kearl *et al.*, 1979 and Maklad, 1996).
With the objective to compare between feeding rice straw or maize stalks as a basal diet on the extent of digestion in the rumen of sheep, the six rations were formulated at the commonly practiced ratios as shown in Table (2). They were formulated to be slightly over the 12% CP necessary for optimal utilization and fermentation of roughage in the rumen (Ørskov *et al.*, 1972). The target of 13-14% CP in the experimental rations were achieved since the ingredients were analyzed before formulating the experimental diets. These were similar to that applied by Hussein *et al.* (1991) to study the effects of carbohydrate and protein sources on animal protein metabolism and carbohydrate fermentation in diets containing 15.5% CP, of which 40% was supplied by SBM. Maeng *et al.* (1976) studied the effects of amino acids on microbial growth, optimum ratio of nonprotein to amino acid nitrogen for microbial growth. They showed that both 100% urea and 100% amino acid in growth media were unfavorable for maximal microbial growth. The optimum ratio of NPN to AA nitrogen for microbial growth was 75% urea-N and 25% AA-N. Kaur *et al.* (1992) showed that under glucose fermentation, the bacterial protein content of the incubation mixture was increased to 3.91, 6.31 and 5.08 times the control value (urea alone) when 25, 50 and 75% of urea-N was replaced with amino acid, respectively. Shain *et al.* (1998) reported that diets containing no supplemental urea were calculated to be deficit in degradable intake protein (DIP) resulting in reduced bacterial synthesis. On the other hand, Milton *et al.* (1997) showed that the supplementation with SBM increased the metabolizable protein and dietary energy utilization, so steers when fed SBM-supplemented diets gained 13% faster and were 9% more efficient converting feed to gain than steers receiving urea. The present study showed that the amino acid-N to urea-N were (70%, 30%), (45%, 55%) and (20%, 80%) for supplemented N-sources (7.5% SBM + 0.5% U), (5% SBM + 1% U) and (2.5% SBM + 1.5% U), respectively, based on that 81% of total N of SBM is in the form of amino acids (Ludden and Cecava, 1995). It is clear therefore that the suitable ratio of amino acid-N to urea-N depends to a large extent on the nature of roughage used to formulate the diet since it was (70%, 30%) for maize stalks, while it was (20%, 80%) for rice straw. Van Soest (1982) has heavily criticized the CF definition and its determination. He developed a new system by which he differentiated the cell and cell wall contents through their solubilities either in neutral

or acid detergents. Such system allows the prediction of cellulose, hemicellulose and lignin. Several investigations applying these procedures were able to correlate the contents of the fiber fractions with digestibility and feeding values of roughage especially with ADF. On the other hand, Buxton and Redfearn (1997) reported that energy availability from forage is limited by fiber concentration because fiber is slowly and incompletely digested, whereas cell solubles are almost completely digested. This proportion of fiber to cell solubles is a major determinant of energy availability in forages. On the other hand, Cecava *et al.* (1988) reported that the nature of basal diet can have a major impact on efficiency of protein utilization for several reasons, first the quality of microbial protein synthesized is influenced by the amount of substrate fermented in the rumen and increased microbial protein synthesis should improve the utilization of digested dietary protein and non protein N; second, degradation of protein in the rumen may be altered by changes in ruminal pH associated with more extensive ruminal fermentation. The present study showed that there was a positive and highly significant correlation coefficient (r = 0.610,) between NFC and DCP intake. On the other hand, as digestion of plant cell walls proceeds in poor quality roughage, polysaccharides are removed and phenolic accumulate forming a protective surface layer that shelters underlying tissues from further attack (Chesson and Forsberg, 1988).

It was clear that the MS was higher in hemicellulose %, and NFC % as compared to RS (Table 1). These differences were related to formulation of the experimental rations (Table 2).

Patton (1994) showed that lignin is negatively correlated with the amount of fiber that can be fermented, while hemicellulose is negatively correlated with the rate at which fiber is digested.

The results also showed that the disappearance % of MS was higher than RS. Hussein *et al.* (1995) showed that the DM disappearance % of alfalfa hay, orchard grass and wheat straw when incubated in the rumen for 24 hr were 52.2, 49.6 and 32.9%, respectively. When MS ration was supplemented with 5% SBM + 1% U its passage rate increased. This can be explained by the more influence of N-source on passage rate of low quality forage than on passage rate of grain or high-quality forage as reported by (Poore *et al.*, 1990). Ead (1999) found that the disappearance % of MS was higher when the ration was supplemented with urea than with SBM. Moreover, Schadt *et al.* (1999) reported that the digestibility decreases associated with increased ruminal turnover rates may be less for nonstructural carbohydrates and protein than for the fiber fractions. When the data of disappearance in the present study was fitted according to the exponential equation of Ørskov and McDonald (1979), it was clear that the degradability (a+b) of DM of MS was significantly increased ($P<0.01$) than RS with increasing urea-N in the rations, but there were no significant effect on the degradability (a+b) of NDF. On the other hand, the degradability (a+b) of ADF for MS when supplemented with (2.5% SBM + 1.5% U) increased cellulose digestibility ($P<0.01$) than the other supplements. Cellulolytic bacteria generally degrade hemicellulose, the products of such degradation may fail to be utilized for growth (Rowett Research Institute, 1996). On the other hand, the ADL% of RS was higher than MS (Table 1). So, Hussein *et al.* (1995) reported that the forage and fibrous by-products are degraded by ruminal cellulolytic bacteria to different extents depending on factors such as cell wall structure and degree of lignification.

It should be pointed out that pH, NH_3-N and VFA in rumen liquor were studied to postulate the suitability for fermentation. The results showed that the cellulose digestibility % decreased ($P<0.01$) when MS ration was supplemented with 5% SBM + 1% U, while the pH values were 5.82 and 5.80 from 4 hr up to 8 hr after feeding, respectively. Hoover (1986) showed that the intensity of the decrease in rumen fiber digestion depends on the length of time at which pH is below 6.0, while the normal range of 6-7 for pH is suitable for the growth and activity of cellulolytic bacteria (Prasad *et al.*, 1972).

Mehrez (1992) reported that optimal NH_3-N concentration for maximal rate of rumen fermentation is associated with dietary source and level of energy to be fermented in the rumen. He found that the optimal NH_3-N concentrations for maximal rate of fermentation in the rumen of sheep fed diets varying in clover hay: barley grains (100:0), (67:33) and (33:67) were 28.70, 31.59 and 30.50 mg/100 ml RL, respectively. The microbial population in the rumen requires a minimum level of ammonia (70 mg/L) to support optimum activity (Ahn, 1990). In the present study, the R:C ratio was almost 60:40. The means of NH_3-N concentration ranged between 21.32 and 19.43 mg/100 ml RL for RS and MS rations, respectively, which would indicate favourite conditions for fermentation of all experimental diets. The VFA concentrations were related more to forage substrate than diet source (Jung and Varel, 1988).

Generally, the present study revealed that NDF digestion remained similar across all diets. But, Stokes *et al.* (1991) reported that nonstructural carbohydrates greater than 24% and ruminally degradable protein greater than 9% of DM will enhance microbial protein flow from the rumen. This indication was suitable for the rations of MS when supplemented with 7.5% SBM + 0.5% U or 2.5% SBM + 1.5% U, which were higher ($P<0.01$) in the rate of NFC intake to DCP intake than other rations. Dennis *et al.* (1983) studied the effect of energy concentration and source of N on a number and type of rumen protozoa. They found that there were larger populations of *Dasytrichs*, which ferment soluble sugars when the diet contained SBM, and larger populations of *Entodinium* of total protozoa, which ferment granular starch when the diet contained urea. On the other hand, Lykos *et al.* (1997) reported that the highest dietary ruminal degradation rate of total NFC increased the amount of nutrients digested in the intestine. Church (1975) indicated that protozoa do result in some differences in rumen metabolism and animal performance. Live weight gain would appear to be improved, possibly as a result of greater digestibility accompanied by higher level of rumen VFA indicating more complete ruminal digestion. The higher levels of ruminal NH_3 observed in some cases might be indicative to greater protein digestion, but it might also be indicative of greater wastage. These indications were related to the present results. In addition, Akin and Borneman (1990) reported that anaerobic fungi produce high levels of cellulases and hemicellulases and are particularly proficient in producing xylanases. These enzymes are regulated by substrate (especially soluble sugars) available to the organisms. Fungi degrade unlignified plant cell walls totally, indicating that enzymes are able to hydrolyze or solubilize the entire plant wall. These organisms are better able to colonize and degrade the lignin – containing tissues than bacteria. However, the effect was not accompanied by an increase in the *In sacco* degradation of wheat straw or an increase in the VFA concentration in rumen contents (Fonty *et al.*, 1995).

On the other hand, prolonged residence is necessary for slow growing organisms such as ruminal fungi and protozoa, with generation times of 5 to 14 hr for ruminal protozoa (Williams

and Coleman, 1988) and 24 to 30 hr for ruminal fungi (Bouchop, 1981).

Stokes *et al.* (1991) reported that the enhanced NDF and DM digestion, VFA production and bacterial efficiencies observed with the narrower ratio of NSC: degradable intake protein. As a result of accelerating fungal growth and metabolism, *Amaferm* increases the rate (or extent) of fiber degradation caused by rumen fungi and that this in turn, may enhanced animal performance. These reports agree with the present investigation results especially when MS ration was supplemented with 5% SBM + 1% U on pH, NH_3-N concentrations and VFA production, but in the other side, DM disappearance % of MS and also DM degradability increased ($P<0.01$) than the other supplements, which caused significant ($P<0.01$) reduction of cellulose digestion of the ration than the other rations. So, Hoover and Stokes (1991) showed that the quantity of ruminally available protein needed to optimize microbial growth may vary under some conditions. Evans (1981 a&b) showed that when high forage diets are fed it may decrease the quantity and efficiency of passage of microbial protein to the small intestine which may be attributed to at least two factors: (1) deficiency of available energy (NSC) will cause slow growth of microbes and greater lysis of microbes in the rumen as a result of slower rate of passage of microbes from the rumen. (2) rate of passage of microbes from the rumen was slower because microbes attach to larger particles and this increase recycling of energy and nitrogen in the rumen. These conditions in the rumen cause larger quantities of energy and N to be utilized for maintenance rather than for growth of the bacteria.

In the present study, the DM, NDF and ADF disappearance % of RS were lower ($P<0.01$) than MS. So, the TDN% of RS rations were lower ($P<0.01$) than the related TDN% value of MS rations. Selective retention of potential fermentable fiber in the rumen is necessary for the maximization of fiber digestion (Allen and Mertens, 1988), and the amount of microbial protein formed in the rumen is related to dietary DE rather than protein (Broderick and Merchen, 1992).

So, the present study suggested that the corn grain "which is high in degradable carbohydrate but relatively low in degradable protein" (Hussein *et al.*, 1991) could be replaced amounts of RS, which was lower in NFC and NFE% than MS, and however, non-fiber source may be useful in providing additional fiber in minimum forage diets and thereby improving cow performance or allowing optimal performance at lower forage amounts (Swain and Armentana, 1994). Moreover, when dietary NDF levels were reduced and starch and sugar levels increased independently, protozoal contribution to NDF degradation generally increased (Dijkstra and Tamminga, 1995). Lykos *et al.* (1997) showed that as ruminal degradation rates of total nonstructural carbohydrates increased, the ruminal NH_3-N concentration and degradabilities of OM and N decreased, and on the other hand, bacterial efficiency tended to increased, intestinal and total tract digestibilities of OM and NSC increased. The inhibitory effect of lignin is closed related to its structure and thus probably affected by modifications, which lignin undergoes in the digestive tract of ruminants, so MS was decreased the potential extent of digestion (Mertens and Loften, 1980) in the rations. This might be benefit on ruminal digestion of all fiber fractions, and to digest the ratio of NSC to DIP around 3:1 (Nocek and Tamminga, 1991). And on the other hand, this will be in agreement with the Ministral decision (Ministry of Agriculture, 1996) which recommended to did not exceed the roughage materials more than 50% of the total mixed ration on DM basis. On the other hand, although the feeding values of the proposed rations in which the roughage constitutes 60% of the ration, yet the feeding values of the proposed rations were not less than 52% TDN.

Such value is recommended and sufficient for local dairy cows and beef cattle during the first stages of growth and generally for ruminants of medium production level (Ministry of Agriculture, 1996).

The results showed that the quality of fermentation was affected by the type of roughage. The microbial activities in the rumen differ according to the type of roughage depending on relationships between NFC intake, degradable protein intake and the type of hemicellulose in the roughage. So, supplemental N-sources, which is varying in NPN: CP rations have more influences on passage rate and DM degradability of low-quality roughage (MS) which was higher in hemicellulose, rich in phenolics and NFC contents than other low-quality roughage (RS). So when feeding on these roughage grains (corn grain) "must be" replaced by amounts of RS to increase NFC content or of amounts of MS to decrease of potential fermentable fiber which may be maximize fiber digestion.

Finally, the present study showed that the rations of : 60% rice straw + 36% concentrate feed mixture + 2.5% soybean meal + 1.5% urea, and 60% maize stalks + 32% concentrate feed mixture + 7.5% soybean meal + 0.5% urea were the suitable for the digestion and fermentation when feeding on like these materials of the low-quality roughage.

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