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EFFECT OF DIETARY NITROGEN AND CARBOHYDRATE SOURCES ON PRODUCTIVE PERFORMANCE IN SHEEP

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SUMMARY

Fifty four growing male Ossimi lambs (averaging 19.8 Kg and 6-7 mo old) were used in a feeding trial to investigate the effect of dietary nitrogen and carbohydrate sources on productive performance in sheep. In addition, a digestibility trial and nitrogen balance were conducted to study the treatment effect on metabolism, rumen characteristics and carcass characteristics. Feeding trial included 9 experimental groups, six animals each. Experimental lambs were fed nine different diets randomly. Three different sources of dietary nitrogen were used in combinations with three different sources of dietary carbohydrate. Results indicated that interaction between dietary protein and carbohydrate sources had a marked effect on growth rate, feed efficiency and some rumen characteristics. Among dietary protein sources, urea caused the highest final body weight (43.0 Kg), ADG (197g) and feed efficiency (5.74 Kg DMI/kg gain). Corn as a dietary source of carbohydrate caused a higher ($P \leq 0.05$) final body weight (43.8-Kg) compared with barley and basal diets. On the other hand barley caused less DM intake and a similar feed efficiency as corn which was better than basal diets. Combining hay and barley in the diets resulted in the highest final body weight and ADG. Feed efficiency values of lambs fed diets containing barley plus urea was the best. It was concluded that synchronization between dietary carbohydrate and protein degradation would maximize their utilization by ruminant animals.

Keywords: Dietary nitrogen and carbohydrate sources, productive performance, carcass characteristics, sheep

INTRODUCTION

When dietary proteins are degraded by rumen microorganisms, the resulting amino acids, volatile fatty acids and ammonia may be utilized for microbial protein synthesis or alternately be wasted as urea in the urine. (Chalmers, *et al.*, 1954, Cocimano and Leng, 1967 and Allison, 1970). Microbial growth and consequently microbial protein synthesis in the rumen is dependent on not only the presence of suitable nutrients (carbon, nitrogen and growth factors) but also timing and synchronization of the presence of these nutrients together. Some studies have demonstrated an increase in total numbers of rumen bacteria and protozoa when the proportion of grain in the diet is increased (Furchtenicht and Broderick, 1987; Oshio *et al.* 1987). In addition, Rode *et al.* (1985) reported increased microbial nitrogen flow to the duodenum when grain in the diet of lactating cattle was increased from 20 to 76%. Moreover, Wanderley *et al.* (1987) found that a high grain diet resulted in more bacterial flow to the duodenum than a low grain diet. On the other hand, earlier studies by Chamberlain and Thomas 1979, Oldham *et al.*, 1979 and Mathers and Miller, 1981 showed a decrease effect on microbial efficiency (yield of microbial protein per kg organic matter fermented) when over 30 % grain was included in the diet. Variation in investigator's findings can be explained by the statement of Hoover (1987) which indicated that microbial growth on diets high in non-structural carbohydrate can be limited by ruminally available protein. Moreover, The efficiency of rumen protein synthesis is not a constant, and changes in it are likely responsible for some variations in animal performance. (Sniffen and Robinson, 1987).
Therefore, the present study was designed to investigate the effect of using three sources of nitrogen (differ in the rate of rumen degradability) in nine combinations with three different sources of carbohydrates in sheep ration on productive performance and feed efficiency in Ossimi male lambs.

MATERIALS AND METHODS

Fifty-four Ossimi growing male lambs weighing 19.8 Kg (6 – 7 mo. Old) were used in this study. Animals were randomly divided into nine experimental groups (6 lambs each). Lambs of each group were fed according to one of the following feeding groups (Table A) using NRC, (1984) allowances:

- Animals of G1 were fed the basal diet (BD) that consisted of concentrate feed mixture (CFM, 87.5%) in addition to berseem (Egyptian clover, 12.5%)

- Animals of G2 and G3 were fed BD where 30% of CFM nitrogen was replaced by either hay (G2) or urea (G3) nitrogen.
- Animals of G4 and G7 were fed BD where 28% of CFM carbohydrates were replaced by either corn (G4) or barley (G7) carbohydrates.
- Animals of G5 and G6 were fed as G4 but 30% of CFM nitrogen was replaced with either hay (G5) or urea (G6) nitrogen.
- Animals of G8 and G9 were fed as G7 but 30% of CFM nitrogen was replaced with either hay (G8) or urea (G9) nitrogen

The CFM was composed of 38% wheat bran, 18% yellow corn, undecorticated cotton seed cake, 8% peanut hulls, 7% rice granules, 5% vinass4% rice hulls, 3% limestone, 4% wheat and bean straw and 1% salt.

Animal live body weight and feed intake were recorded on weekly basis through the entire experimental period (117 days).

Table A. The composition of the different experimental group diets, g/kg

Ingredients	Experimental groups								
	G1	G2	G3	G4	G5	G6	G7	G8	G9
CFM	875	675	863.4	625	425	613.4	625	425	613.4
Hay	0.0	200	0.0	0.0	200	0.0	0.0	200	0.0
Urea	0.0	0.0	11.6	0.0	0.0	11.6	0.0	0.0	11.6
Corn	0.0	0.0	0.0	250	250	250	0.0	0.0	0.0
Barley	0.0	0.0	0.0	0.0	0.0	0.0	250	250	250
Berseem	125	125	125	125	125	125	125	125	125

A digestibility trial was conducted using three mature lambs for each experimental group. Each animal was adapted to metabolic crates for ten days followed by seven days as a collecting period. Rumen fluid samples were taken from randomly chosen three lambs of each group before morning feeding (at 0-time) and after 2, 4 and 6 hours post-feeding twice through the entire experimental period. Rumen fluids were obtained by using stomach tube with an aid of vacuum pump. Samples were strained through four layers of cheesecloth. Rumen pH was estimated immediately using a portable pH meter, (HANNA, model E11-7010) then 2 ml of toluene and 2 ml of paraffin oil were added to the samples and were kept frozen (at -20°C) till determination of NH3-N by Semi- micro Kjeldahl method, (A.O. A. C., 1990). Total volatile fatty acids were determined according to Kromann *et al.* (1967). Samples of ingredients included in the diets and feces were analyzed for moisture, crude protein, ether extract, crude fiber and ash by the ordinary method of A.O.A.C. (1990). Three animals (randomly chosen from each group) were deprived from feeding and water for 16 hours before slaughter time. After complete bleeding, slaughtered lambs were skinned out and hot carcass and the different offals (heart. liver and kidneys) and organs (head and tail) were weighted immediately. Subcut fat thickness was estimated by measuring thickness of fat covering *longissimus dorsi* in three different locations and taking the average of the three resdings. A regular rule was used.

Statistical analysis was carried out by using factorial (3X3) model with interaction (SAS) Linear program (1995).

Table 1. Chemical analysis of the experimental concentrate mixtures used (DM, basis, g/kg)

Experimental Groups	OM	CP	CF	EE	NFE	Ash	TDN
G1 (BD)	881	111	151	33	586	119	694
G2 (BD+ hay)	873	119	184	32	538	127	654
G3 (BD+ urea)	896	124	150	33	589	104	689
G4 (BD +corn)	904	111	124	35	634	96	719
G5 (BD + corn +hay)	890	119	158	34	579	110	679
G6 (BD + corn +urea)	926	124	98	37	667	74	737
G7 (BD+ barley)	893	113	137	31	612	107	706
G8 (BD + hay + barley)	885	121	170	30	564	115	666
G9 (BD + barley +urea)	932	128	122	42	640	68	713

RESULTS AND DISCUSSION

Date of Table 2 indicated that diets containing urea as a nitrogen source caused significantly ($P \leq 0.05$) the highest final weight (43.0Kg). Consequently higher ADG, (197g) and relative gain (116%. final weight / initial weight) compared with hay diets, (38.6 kg, 162 g and 196%, respectively). While lambs fed CFM-N diets caused intermediate values.

Table 2. Effect of dietary nitrogen and carbohydrate sources on the productive Performance of the experimental groups

Experimental Groups	Growth rate					Daily feed intake, gm			FE
	IW (kg)	FW, kg	TG, kg	ADG, g	RG	DMI	CPI	TCAR**	
G1, G4 & G7(CFM-N) diets	19.7	40.4^{ab}	20.7^{ab}	177^{abcd}	1.05^{ab}	1213^{a}	135^{a}	905^{b}	6.85^{b}
G2, G5 & G8 (CFM +Hay)-N. diets	19.7	38.6^{b}	18.9^{b}	162^{b}	0.96^{b}	1413^{a}	168^{b}	1055^{a}	8.72^{a}
G3, G6,G9 (CFM + Urea)-N. diets	19.9	43.0^{a}	23.1^{a}	197^{a}	1.16^{a}	1131^{c}	150^{c}	847^{c}	5.74^{c}
SE	±0.87	±1.34	±0.9	±0.9	±077	±56	±6	±31	±1.20
G1, G2 & G3 (CFM-CAR.*) diets	19.2	38.5^{b}	19.3^{b}	165^{b}	1.01	1307^{a}	157^{a}	954^{a}	7.92^{a}
G4, G5, G6 (CFM +corn)-CAR* diets	20.3	43.8^{a}	23.5^{a}	201^{a}	1.16	1289^{a}	155^{a}	966^{a}	6.41^{b}
G7, G8, G9 (CFM +barley)-CAR.* diets	19.8	39.8^{b}	20.0^{b}	171^{b}	1.01	1160^{b}	143^{b}	866^{b}	6.78^{b}
SE	±0.84	±1.31	±0.13	±.01	±.08	±50	±5	±32	±1.18

a, b, c, d = means within the same column with different superscript differ ($P< 0.05$)

* Carbohydrate, ** TCAR = total carbohydrate IW = initial weight, FW = final weight, TG= total gain, ADG = average daily gain, FE = feed efficiency (kg DMI/kg gain), RG = relative gain (total kilograms gained divided by IW), SE = standard error of the Mean

Partial replacement of CFM carbohydrate by corn carbohydrate improved significantly ($P \leq 0.05$) ADG (201 g) of lambs comparable to those fed CFM only (165 g) or CFM partially replaced with barley (171 g). The same trend was noticed for final weight, total gain and relative gain.

Data in the same table reveal that both DMI and CPI values of lambs fed diets containing CFM plus hay nitrogen were significantly ($P \leq 0.05$) the highest (1413, 168 g/d). While those fed urea containing diets had the lowest values (1131, 150g/d, respectively). Feed efficiency values measured as kg DMI per one kg gain indicated that lambs fed diets containing urea had significantly ($P \leq 0.05$) the best value (5.74 kg DMI) while those fed diets containing hay nitrogen consumed 8.72 kg DMI to gain one kg. Flachowsky *et al.* (1986) obtained similar results on sheep using wheat straw treated with sheep urine and Gado (1997) on goats using ammonia treated rice straw. High microbial protein synthesis and consequently higher efficiency in growth performance can explain results with diets containing urea since the CFM contained enough available carbohydrates. Urea diets contained 62.53% NFE vs. 60.88 and 57.68% for basal diets and hay diets, respectively.

However, DMI and CPI values of lambs fed CFM carbohydrates diets or partially replaced by corn diets were similar. While those fed on CFM and barley carbohydrates diets had significantly ($P \leq 0.05$) the lowest values. Feed efficiency values for lambs fed both corn and barley diets were similar (6.41, 6.78 kg DMI/ kg gain) and significantly ($P \leq 0.05$) better than those of basal diets (7.92 kg DM / kg gain).

Results obtained by the present study were in agreement with Mc Carthy *et al.* (1989) who reported higher DMI and CPI with corn diets than barley diets. On the other hand, Flachowsky (1986) found no significant difference in DMI when animals were fed either corn or barley while CPI was higher with barley diets. However, agreement and disagreement would on the variety of grain used and kind of fibers used which are reflected on starch and CP contents in grains.

Effects of interaction between dietary nitrogen and carbohydrate sources on growth performance and feed efficiency indicated that diet G8 that contained hay as a nitrogen source and barley as a carbohydrate source caused the highest ($P \leq 0.05$) ADG (226g). However barley and urea combination, in the diet (G9) caused 207 g ADG with no significant difference between G8 and G9. Nevertheless, G9 had the lowest ($P \leq 0.05$) DMI among the groups (1054 g/d), while G2 (BD + hay) had the highest value of DMI (1521g/d) and CPI (180g/d). Feed efficiency (FE) values for G8 & G9 were not significantly differ although G9 tended to be better. In other wards, diets containing barley either with hay or urea nitrogen consumed less ($P \leq 0.05$) amount of DM to produce one unit of the growth. McDonald *et al.* (1982). Considered that the differences in feed utilization efficiency and feed intake on different rations could be attributed mainly to the quality and quantity of available carbohydrates. Also, Kreikemeier *et al.* (1987) observed increases in feed intake and decrease in feed efficiency when they fed reconstituted sorghum grain at 20% moisture level. to lambs These findings agree with the present results where high intake observed for G2 for example was followed with low feed efficiency for the same diet.

Date in Table 4 indicated that there were no significant effects due to the partial replacement of basal diet protein with hay or urea protein on either DM or CF digestion. However, hay and urea increased significantly CP digestion when compared with control basal diet. The values were 77.0, 77.1 and 76.4 %, respectively. Nitrogen balance was positive for all nitrogen sources and was high for hay and urea diets (6.07, 6.40 g/d) compared with basal diet (5.94g/d). Dietary carbohydrate source had a remarkable effect on DM digestion, where corn significantly ($P \leq .05$) increased digestion (77.6%) while barley decreased it (75.5%) compared to basal diet (76.4%). Crude protein digestion was improved significantly with corn or barley (77.1, 77.4%) vs basal diet (75.9%). Corn carbohydrates did not affect crude fiber digestion (47.9%). While barley decreased it (46.3%) compared with the basal diet (48.8%). Nitrogen balance values were positive for all carbohydrate sources and it was the highest for corn diet (6.27g/d) and lower for barley and basal diets (6.09, 6.02g/d respectively). Effects of interaction between dietary carbohydrates and proteins on apparent digestibility of nutrients are shown in Table 5. Date in the table indicated that combining corn as source of carbohydrate with urea as a nitrogen source (G6) increased both DM and CP digestibilities (78.6%, 78.5%) when compared with G1 (basal diet, 75.6%, 75.6% respectively). Crude fiber digestibilities for diet 4 and 6 were 47.9 and 47.6%, respectively and were significantly higher ($P < .05$) than these of G7, G8 and G9 (46.1, 46.3 and 46.5%, respectively). However, G1, G2, G3 and G5 had significantly the highest CF digestibilities among the diets and they were similar to each other.

Table 3. Effect of different nitrogen and carbohydrate sources and its interactions on growth parameters and feed efficiency of the experimental lambs

Experimental Groups	IW. kg	FW. kg	TG. kg	ADG. g	RG	DMI. g d	CPI. g d	FE
G1 (BD)	18.6	40.4^{ab}	21.8^{abcd}	186^{abcd}	1.17^{ab}	1301^{b}	144^{c}	6.99^{c}
G2 (BD+ hay)	20.5	41.6^{ab}	21.1^{abcd}	180^{abcd}	1.03^{ab}	1521^{a}	180^{a}	8.45^{ab}
G3 (BD+ urea)	19.9	39.2^{b}	19.3^{bcd}	165^{bcd}	0.97^{b}	1100^{d}	145^{c}	6.67^{c}
G4 (BD +corn)	19.1	36.4^{b}	17.3^{cd}	148^{cd}	0.91^{b}	1132^{d}	126^{e}	7.65^{bc}
G5 (BD + corn +hay)	20.2	43.2^{ab}	23.0^{abc}	196^{abc}	$1.14a^{b}$	1496^{a}	177^{a}	7.63^{bc}
G6 (BD + corn +urea)	19.9	36.3^{b}	16.4^{d}	140^{d}	0.82^{b}	1239^{c}	163^{b}	8.85^{a}
G7 (BD+ barley)	19.9	38.8^{b}	18.8^{bcd}	161^{bcd}	0.95^{b}	1206^{c}	136^{d}	7.49^{bc}
G8 (BD + hay + barley)	20.1	46.6^{a}	26.5^{a}	226^{a}	1.32^{ab}	1219^{c}	147^{c}	5.39^{d}
G9 (BD + barley +urea)	19.6	43.8^{ab}	24.2^{ab}	207^{ab}	1.23^{ab}	1054^{e}	143^{c}	5.09^{d}
SE	± 1.45	± 2.08	± 1.65	± 14	± 0.12	±42	±5	±30

a,b,c,d Means within the same column with different superscript differ ($P< 0.05$)

Table 4. Effect of different nitrogen and carbohydrate sources on nutrient digestions (g/kg) and nitrogen balance (g/d) by the experimental lambs

Experimental Groups	DM	CP	CF	NFE	NB
G1. G4 & G7(CFM-N) diets	766	764^{a}	477	768	5.94
G2, G5 & G8 (CFM +Hay)-N, diets	767	770^{b}	477	774	6.07
G3, G6, &G9 (CFM + Urea)-N, diets	763	771^{b}	475	769	6.40
SE	±0.6	±0.5	±1.1	±1.2	
G1, G2 & G3 (CFM-CAR.*) diets	764^{b}	759^{a}	488^{a}	769	6.02
G4, G5 & G6 (CFM +corn) –CAR.* diets	776^{a}	771^{b}	479^{a}	774	6.27
G7, G8, & G9 (CFM +barley) –CAR.* diets	755^{c}	774^{b}	473^{b}	769	6.09
SE	±0.5	±0.5	± 1.2	± 1.3	

a,b,c Means within the same column with different superscript differ ($P< 0.05$)

* Carbohydrate

Table 5. Effect of different nitrogen and carbohydrate sources and its interactions on nutrient digestibility (g/kg) and nitrogen balance (g/d) of the experimental lambs

Experimental Groups	DM	CP	CF	NFE	NB
G1 (BD)	75.6^{dc}	75.6^{cd}	49.1^{a}	76.6^{c}	5.90
G2 (BD+ hay)	77.9^{b}	77.9^{b}	48.8^{a}	78.9^{a}	6.10
G3 (BD+ urea)	75.8^{d}	74.1^{e}	48.5^{a}	75.2^{c}	6.05
G4 (BD +corn)	77.2^{c}	76.7^{c}	47.9^{b}	77.0^{b}	6.11
G5 (BD + corn +hay)	77.1^{c}	76.1^{d}	48.1^{a}	76.6^{b}	6.21
G6 (BD + corn +urea)	78.6^{a}	78.5^{a}	47.6^{b}	78.6^{a}	6.49
G7 (BD+ barley)	76.9^{c}	76.8^{c}	46.1^{c}	76.9^{b}	5.80
G8 (BD + hay + barley)	75.1^{e}	76.9^{c}	46.3^{c}	76.8^{b}	5.91
G9 (BD + barley +urea)	74.6^{e}	78.6^{a}	46.5^{c}	76.9^{b}	6.56
SE	±0.6	±0.5	± 1.15	± 1.25	

a, b, c Means within the same column with different superscript differ ($P< 0.05$)

Data in Table 6 indicated that rumen pH in animals fed hay nitrogen had a lower pH value than those fed either basal or urea diets. Objective of the present study was to investigate the sources of dietary carbohydrate that can be coupled with sources of dietary nitrogen to result in higher animal performance. Since the animal performance is the reflection of the nutrient metabolism, then the effect of dietary sources interaction on the animal performance can be explained by parameters of nutrient metabolism .The data obtained in the present study indicated that the combination of barley with hay

(G8) in the diet resulted in the best final weight consequently, ADG and relative gain (RG, total kilograms gained by animals divided by IW). Since RG was calculated to show the ability of the animal to increase its total gain (TG). The result indicated those animals fed hay with barley (G8) were the best apart of its FW. At the same time, lamb of G8 that had hay with barley showed a low feed intake (g/d) which resulted in the best efficiency. This performance may be due to the highest utilization of digested material. Digestion of nutrients in this group (G8), however, was the best and that be explained by lower pH value in the rumen which was a result of highly fermented starch in barley. Results of carcass characteristics appeared that animals of G8 gave one of the best dressing percentage with low tail weight and kidney fat weight. However, subcutaneous fat thickness was high indicating that animals of this group tended to deposit fat at the end of fatting period and it was excepted to have high lean percentage. However, lean and fat percentages were not measured in the present study. From the above, it can be concluded that starch of the barley with nitrogen of the hay present the best synchronization between dietary sources of nitrogen and carbohydrate. On the other hand, animals of G3 (BD with urea) showed the highest DMI (g/d) and a moderate value of ADG and feed efficiency (Table 3& 4). Low nutrients digestion of this group must be accompanied by low utilization of digested nutrients. Although, rumen pH value and ammonia concentration were high, TVFA's were low in the rumen. At the same time, dressing percentage was the lowest. It could be concluded that urea alone with BD and without an extra source of highly fermentable carbohydrate like corn or barley resulted in poor animal performance. However, urea as a source of NPN resulted in higher animal performance when it was fed with barley (G9) than when it was fed with corn (G6) or when it was fed alone (G3). The conclusion of the present study and the explanation of the results agree with those of Marten *et al.* (1981); Williams *et al.* (1984) and Hoover (1987). The previous investigators stated that NPN source can be utilized with levels based on rations content and metabolic source of readily available carbohydrate. Moreover, Flachowsky *et al.* (1986) concluded that OM and CP digestibilities were improved when concentrates were added to forage of sheep diets. On the other hand, DePeters and Tylor (1985) stated that barley and corn had the same effect on their milk yield and composition when fed to dairy cows.

Table 6. Effect of dietary nitrogen and carbohydrate on rumen parameters of the experimental lambs

Experimental Groups	Rumen-pH	Rumen NH3, mg/100 ml	Rumen TVF,s m.eq/100ml
G1, G4 & G7(CFM-N) diets	5.94[a]	13.2[a]	5.36
G2, G5 & G8 (CFM +Hay)-N, diets	5.63[b]	14.2[a]	5.18
G3, G6, &G9 (CFM + Urea)-N, diets	5.81[a]	15.8[b]	5.26
SE	±0.2	±1.5	±0.53
G1, G2 & G3 (CFM-CAR.*) diets	6.14[a]	14.6	4.74[a]
G4, G5 & G6 (CFM +corn) –CAR.* diets	5.56[b]	14.5	5.09[a]
G7, G8, & G9 (CFM +barley) –CAR.* diets	5.68[b]	14.0	5.97[b]
SE	±0.22	±1.4	±0.51

[a, b, c]Means within the same column with different superscript differ ($P < 0.05$)

* Carbohydrate

Table 7. Effect of dietary nitrogen and carbohydrate on carcass characteristics of the experimental lambs

Experimental Groups	LBW, kg	Carcass, W, kg	Dressing, %	Tail W.	Sub cut fat thickness, mm
G1, G4 & G7(CFM-N) diets	40.2[ab]	22.0[b]	54.7	2.06	4.50
G2, G5 & G8 (CFM +Hay)-N, diets	39.0[b]	21.7[b]	55.6	2.01	4.62
G3, G6, &G9 (CFM + Urea)-N, diets	42.6[a]	23.8[a]	55.9	2.03	4.43
SE	1.35	0.95	1.17	0.15	0.28
G1, G2 & G3 (CFM) CAR.* diets	38.5	21.4	55.6	2.00	4.36
G4, G5 & G6 (CFM +corn) –CAR.* diets	43.7	24.1	55.1	2.07	4.60
G7, G8, & G9 (CFM +barley) –CAR.* diets	39.7	22.0	55.4	2.04	4.59
SE	±1.30	±0.90	±1.17	±0.15	±0.28

a, b & c = means within the same column with different superscript differ ($P < 0.05$)

* Carbohydrate

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