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EVALUATION OF BIOLOGICAL TREATMENTS FOR AGRICULTURAL BY-PRODUCTS IN RUMINANTS FEEDING. II- DIGESTIBILITY STUDY

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ABSTRACT

To estimate the digestibility coefficients, nutritive values, nitrogen balance and some ruminal and blood constituents of rams fed biologically treated roughages. The obtained results could be summarized in the following:

- Rice straw (RS) was more digestible for OM, CP, EE, CF, NFE, ADL, cellulose and hemicellulose. It also was more consumable as DM and different nutrients. It led to lower drinking water consumption and to higher urine excretion and N-balance.
- The RS was responsible for higher ruminal ammonia and lower ruminal TVFA and microbial protein concentrations. It gave also higher blood total protein and globulin and lower blood urea concentrations.
- Fungus + soybean meal was the best treatment concerning the digestibility of the treated roughage (OM, CP, EE, CF, NFE, ADF, ADL, cellulose and hemicellulose) and their feeding values (TDN, SV and DCP). It led also to the highest feed and nutrients intake as well as urine excretion and N-balance and to the lowest water consumption.
- Fungus + soybean meal treatment reflected the highest ruminal pH, ammonia, and microbial protein and the lowest TVFA values. It gave also the highest blood total protein concentration and the lowest blood serum AST activity.

Conclusively, the biological treatment with the white rot fungi, particularly with the fungus *Pleurotus ostreatus* of the field wastes (roughages) can improve their digestibility, and nutritive value. So, fungal treatment of agricultural by-products can offer unconventional animal feed which is economical and environmentally friend without any negative effects on animal health.

Keywords: Biological treatments, Agricultural by-products, *In situ* disappearance, Digestibility, Rumen, Blood, N-balance.

INTRODUCTION

Every year in several countries such as Egypt, many millions tons of carbohydrate remain unused as cellulosic wastes in fields and factories, because there are no simple technique which allow to utilize such agricultural wastes. In Egypt, the agricultural by-products are considered as stable source of ruminant feeds and now a days interest in their effective utilization is increasing all over the world due to economical factors and pollution. In Egypt there are about 27822497.6 tons of Agriculture, residues, (Agriculture Research Center, Ministry of Agriculture, Egypt, 2002), are five another important roughages produced in desert could be used as an animal feeds. Approximately two thirds of the crop residues are burned or wasted, and hence lead to environmental pollution and consequently health hazards.

Utilization of such by-product can not only be used in favor of solving feed shortage problem but also as a method to control environmental pollution (Zaza, 2004). Feeding is the most important cost item for livestock production which represents about 70% of the total production costs (Borhami and Yacout, 2001). The degree of signification is relatively more important in controlling hydrolysis rate in animal digestive tract (Fan *et al*., 1981). Therefore, there are many methods for improving the nutritive value of these by-products like as physical, chemical, physic-chemical and biological treatments. Biological treatment is used for increasing the nutritional value of many by-products, because they have significant concentrations of simple carbohydrates, such as mono-and disaccharides. For these reasons the microbial conversion of these wastes can improve their nutritional value and transforming them into animal feed with high quality (Villas-Boas *et al*., 2002). Many efforts have been employed to remove the lignin and/or to break up the linkages between lignin and carbohydrates and to increase their feed values by biological treatments (El-Shafie *et al*., 2007; Abo-Eid *et al*., 2007 and Abo-Eid, 2008). The main objectives of this study were to estimate the effect of feeding biologically treated rice straw and corn stalks on the digestibility coefficients, nutritive values, nitrogen balance and some ruminal and blood parameters of rams.

MATERIALS AND METHODS

Animals and feeds:

Eighteen Ossimi rams aged 2 – 2.5 years with 55.5 $\pm$ 5 Kg average body weight were divided into six similar groups (3 animals in each, on the basis of average live body weight) to evaluate the following rations No.:

1- 60% of energy and crude protein requirements according to NRC (1985) as concentrate feed mixture (CFM) plus untreated rice straw *ad*. *libitum* (control).
2- 60% of requirements as CFM plus fungal *Pleurotus ostreatus* (P.o) treated rice straw *ad*. *libitum* (T_1).
3- 60% of requirements from CFM and P.o treated rice straw + 2.5% soybean meal *ad*. *libitum* (T_2).
4- 60% of requirements from CFM and untreated cron stalks *ad*. *libitum* (control).
5- 60% of requirements from CFM and fungal (P.o) treated cron stalks *ad*. *libitum* (T_1).
6- 60% of requirements from CFM and fungal (P.o) treated cron stalks + 2.5% soybean meal *ad*. *libitum* (T_2).

The daily feed intake values of untreated and treated roughages were determined during the preliminary period of the digestibility trails. Afterwards, 90% only from the *ad libitum* intake were offered to the rams during the collection period. The animals were fed individually in metabolism cages. Fresh drinking water was available at all times the day and daily water consumption was recorded for each individual animal. Each trial lasted 30 days, 20 days as a preliminary period and 10 days as a collection period, 7 days feces and urine collection and 3 days for rumen and blood samples collection.

Feces and urine collection:

Feces and urine were collected quantitatively and daily during the collection period. Representative constant samples of fresh feces (10%) were collected daily, sprayed with diluted sulfuric acid (10%) and dried for 24 hours at 60 ºC then ground, mixed and kept for chemical analysis. Also, the daily collected urine samples were mixed with 100 ml diluted sulfuric acid (10%) and stored for nitrogen determination. The chemical analysis of ingredients, diets, residuals of feed, feces and urine were determined according to A.O.A.C (1990).

Rumen liquor samples:

Rumen liquor samples were obtained, using stomach tube, at the end of collection period (three days) from each animal three times, just before morning feeding (zero time), 3 and 6 hrs post feeding. Rumen liquor was strained through four folds of cheese cloth and immediately rumen pH values were measured using pH meter (Orion Res. EARH Model 30). The ruminal NH_3 -N was determined according to Conway (1962). Then, two drops of toluene and a thin layer of paraffin was added to liquor, then the liquor was stored in a deep freezer at (-20 ºC) until chemically analyzed. Total volatile fatty acids were determined by steam distillation methods as described by Warner (1964). Microbial protein was estimated by sodium tungistate method according to Shultz and Shultz (1970).

Blood serum samples:

Blood serum samples were collected from the Ossimi rams as well as from lambs. Blood serum samples were collected at the end of the collection period from each animal. Samples were obtained by allowing blood to flow feely from the jugular vein through a clean dry needle into 10 ml test tubes. Blood was left at room temperature for 45 – 60 min then centrifuged at 4000 r.p.m for 20 minutes to separate the serum into clean dried glass vials (8 – 10 ml) and stored frozen at (–20ºC) for subsequent analysis. Estimation of total protein was done according to Henry *et al*. (1974). Determination of albumin (A) was carried out according to the method of Doumas *et al*. (1971). Calculation of globulin (G) was done by subtracting albumin concentration values from total protein values (El-Nouty *et al*., 1984). A/G ratio was calculated. Urea was estimated according to Young (2001). Creatinine was conducted according to Bartels (1971). Alkaline phosphatase activity was measured according to the method of Beliefield and Goldberg (1971). Activities of transaminases [aspartate animal transaminase (AST) and alanine amino transaminase (ALT)] were determined according to Reitman and Frankel (1957). All blood analyses were carried out calorimetrically using commercial kits from the local market (Meriewx-France).

Statistical analysis:

The obtained data were analyzed according to Statistical Analysis System user's Guide (SAS, 1998) for one way analysis of variance. Separation among means was carried out by using Duncan's (1955) multiple range test. Data of chemical composition, gross energy, fiber fractions and in situ dry and organic disappearance were analyzed according to factorial design.

RESULTS AND DISCUSSION

The second part of this thesis aimed to study the effects of the best treatment from the first part of this thesis, depending on the annual quantity available locally from the crop by-products, and the response of the chemical composition, gross energy and cell wall constituents to the biological treatments and additives used. Since PS less available; so, CS and RS were chosen to be treated biologically with *P. ostreatus* (as the best fungus tested) in the presence or absence of 2.5% soybean meal for studying their effects on the digestibility, feed and drinking water consumption, rumen liquor parameters, and blood picture by Ossimi rams. Table 1 shows that digestibility coefficients of OM, CP, CF and EE were significantly ($P \leq 0.001$) affected by crop residual type, in favor of RS; yet, it gave lower DCP than CS, but TDN and SV did not significantly differ. The treatments also affected significantly both digestibility and nutritive values of the tested crop residues. Since fungal treatment (T1) and fungal + soybean meal treatment (T2) elevated the digestibility of all nutrients as well as the nutritive values expressed as TDN, SV and DCP. T1 was more better than T2 concerning digestibility of DM, but T2 was more effective on OM and CP digestibility coefficients as well as all forms of nutritive values. Yet, T1 and T2 were significantly similar in digestibility of CF, EE, and NFE (Table 1). The interaction effect between crop residues type and treatments on digestibility of the nutrients and the feeding values was significant. This Table shows that T1 was better than T2 in DM digestibility of both CS and RS; whereas T2 was better than T1 in OM, CP, CF and NFE digestibility and all forms of the nutritive values of both CS and RS. Table 1 clears that RS was superior ($P \leq 0.001$) in digestibility of either of OM, CF and EE, but CS was more digestible ($P \leq 0.001$) in NFE and more nutritive ($P \leq 0.001$) either as TDN, SE or DCP. The combined treatment (T2) was more ($P \leq 0.001$) better than T1 in all nutrients digestibility and nutritive values, except for DM and CF digestibility.

Digestibility coefficient of cell wall constituents as affected by crop residual type and/or treatments are given in Table 2. From this Table, RC and CS were not significantly different from each other in NDF and ADF, but RC was superior ($P \leq 0.001$) in ADL, cellulose, and hemicellulose digestibility. Also, both T1 and T2 were better than the untreated (control), particularly T2 ($P \leq 0.001$). Data of the effects on digestibility of cell wall constituents of the interaction between either variables studied (crop residual type x treatments) show also significant ($P \leq 0.001$) differences among treatments in both crop residual types, with superiority of T2 on T1 for all constituents of CS and RS, except the digestibility of NDF of RS, where T1 was significantly better than T2.

Both types of the crop residues used did not significantly differ from each other in DM intake from either concentrate mixture or roughage, or total intake as g/Kg/$W^{0.75}$, g/Kg/animal, SE,or TDN;but CS led to significantly higher total DM intake but lower TDN intake (as g/h/d), DCP (as g/h/d and/$W^{0.75}$), TDN/animal and DCP/animal (Table 3).

1+2

T2 realized higher values ($P \leq 0.001$) for all criteria calculated in Table 3 comparing with T1 (and in most cases also with the control). Yet, the untreated (control) was superior significantly in cases of total DM intake, g/Kg/animal and DCP/$W^{0.75}$. The interaction effect between type of crop residues and treatment was calculated and was significant, whether on body weight, metabolic body weight, or feed intake.

Water intake and urine excretion were both significantly influenced by crop residual type as well as by the treatments tested as shown from Table 4. Corn stalks was responsible for significantly better body weight, metabolic body mass, and water intake as l/h/d, ml/Kg BW and ml/Kg W-0.82 but lower % urine of water intake. Both treatments (T1 & T2) were better affecting body weight, metabolic body mass, and water intake (except as ml/g DM intake) but lowered the urine excretion than the control (untreated).

The nitrogen balance was not significantly affected by crop residual type but by the treatments, since both of T1 and T2 gave higher N-balance as g/d (Table 5). This effect was clear also from Table 18 of the interaction effect between crop residual type and treatment on N-balance.

Data of rumen liquor parameters as affected by crop residual type, treatment, and sampling time are given in Table 6. Regardless to treatment or time of sampling, pH values did not influence by crop residual type, but CS was responsible for significantly ($P \leq 0.001$) lower NH_3 -N and higher total volatile acids (TVFA) and microbial protein (MP) concentrations than RS. Both of T1 and T2 gave higher ($P \leq 0.001$) values for the tested parameters than the control, particularly T2 for pH and NH_3 -N or T1 for TVFA and MP. The ruminal activity increased 3-h post-feeding, thus there were significant ($P \leq 0.001$) decrease in pH values and increases in either NH_3 -N , TVFA or MP concentrations. These alterations took the opposite trends 6-h post-feeding.

Blood biochemical parameters estimated at the end of the digestibility trials are given in Table 7. There were significant effects of either crop residual types (except on total protein, creatinine and the three enzymes) or treatments (except on globulin, A/G ratio, creatinine, ALT and alkaline phosphatase) on these criteria measured, in favor of RS and treatments against CS and the control (untreated).

In situ disappearance of dry matter and organic matter increased significantly by increasing the incubation period of roughages in the rumen (Bendary *et al*.,2002). Biological treatment increases the in situ disappearance(Abo-Eid *et al.,*2007), particularly by increasing the fermentation period, depending on the organic waste type (Abo-Eid, 2008).

Dry matter intake is influenced too by the type of microorganism used in the biological treatment (Subhash *et al.,* 1991) as well as by the roughage type (Belewn and Ademilola, 2002). However, fungal treatment may increase (Bassuny *et al.,* 2005) or decrease (El-Ashry *et al.,* 1997) the intake of dry matter (Kholif *et al.,* 2005 and Mahrous, 2005) depending on the fungal species used for the biological treatment.

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5-6-7

Differences also were significant in digestibility of different nutrients as well as in the nutritive values, feed and nutrients intakes, body weight, drinking water consumption, urine excretion, N-balance, rumen liquor parameters and blood biochemicals due to variations of roughage type and treatment. Hence, fungal treatment improved digestibility of different nutrients and N-balance of roughages (El-Sayed *et al.,* 2002 and Hamza *et al*., 2005) as well as the nutritive values (Marghany *et al.,* 2004; Bassuny *et al.,* 2005 and Zaza *et al*., 2008).

Water intake changes as l/h/d or ml/Kg W0.82 are depending on the biological treatment (fungal strain) as reported by Bassuny et al. (2005). It may be increased (Subhash *et al.,* 1991 and Fouad *et al*., 1998) or decreased (Abdelhamid *et al*., 2006) by the biological treatments.

Similar trends of changes in rumen liquor parameters by time were recorded by Deraz (1996) and El-Ashry *et al*. (1997). The biological treatments led to variable effects on rumen liquor parameters (Abdelhamid *et al*., 2006 & 2007 and Gado *et al*., 2006).

Although, all values obtained herein for blood biochemical parameters were within the normal ranges according to Kaneko (1989), biological treatment of agricultural by-products may cause no significant effect on blood parameters (Abdelhamid *et al.,* 2006 & 2007) and did not cause any abnormal conditions in liver and kidney functions (El-Ashry *et al.,* 2001 and Abdelhamid *et al*., 2006). But it may also alter (positively or negatively) these metabolites (Marghany *et al*., 2004 and Kholif *et al.*, 2005).

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تقييم المعاملات البيولوجية للمخلفات الزراعية فى تغذية المجترات:
٢ ــ دراسة معامل الهضم

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تم إجراء ستة تجارب هضم على ذكور الأغنام الأوسيمى تامة النمو لتقييم أثر المعاملات البيولوجية على المخلفات الزراعية. ويستخلص من هذه الدراسة:

١- المعاملات البيولوجية أدت إلى تحسن القيمة الغذائية للمخلفات الزراعية، وأظهرت النتائج إمكانية استخدامها بدلاً من ٤٠% من العليقة المركزة دون ظهور أى آثار سلبية على صحة وأداء الحيوان.

٢- المعاملات البيولوجية باستخدام فطر *Pleurotus ostreatus* فقط أو مع إضافة ٢,٥% كسب فول صويا على قش الأرز وحطب الذرة سهلة ولا تحتاج إلى أى إعداد خلاف التعقيم فقط.

٣- كما تشير نتائج الدراسة إلى عدم ظهور أية تأثيرات غير مرغوبة أو ضارة بصحة وإنتاجية الحيوانات نتيجة لاستخدام هذه المخلفات المعاملة بيولوجياً.

Table (1): Effect of crop residual type, treatment and additive (regardless to the other variable) on digestibility coefficients and nutritive values of the experimental rations (% DM basis, means ± SE).

Items	Crop residual type		Treatment		
	Corn stalks	Rice straw	Untreated	T1	T2
Digestibility coefficient:					
DM	58.56A ± 0.673	59.250A ± 0.751	56.32C ± 0.266	60.93B ± 0.312	61.45A ± 0.356
OM	59.20B ± 1.031	60.809A ± 1.199	55.63C ± 0.221	61.77B ± 0.529	62.61A ± 0.498
CP	58.84B ± 1.101	60.728A ± 1.321	55.49C ± 0.434	60.30B ± 0.335	63.57A ± 0.852
CF	52.36B ± 1.644	55.617A ±1.212	48.39B ± 1.508	56.43A ±0.819	57.13A ± 0.383
EE	67.54B ± 0.127	68.610A ± 0.670	66.74B ± 0.257	68.67A ± 0.702	68.83A ± 0.432
NFE	61.78A ± 0.772	62.360A ± 1.025	58.64B ± 0.170	63.43A ± 0.315	64.14A ± 0.540
Nutritive values:					
TDN	54.42A ± 0.7001	53.90A ± 0.7094	51.56C ± 0.4093	54.95B ± 0.2629	55.98A ± 0.2104
S.V	40.64A ± 0.9277	39.86A ± 1.2004	36.28C ± 0.5678	41.19B ± 0.3124	43.28A ± 0.2096
DCP	7.61A ± 0.4587	7.37B ± 0.4148	5.90C ± 0.0690	7.75B ± 0.2054	8.83A ± 0.0189

A, B and C : Means in the same row with different superscripts are significantly (P < 0.001) different.
T1 = *P. ostreatus* treatment, **T2 = *P. ostreatus* + 2.5% soybean meal**

Table (2): Effect of crop residual type and treatment (regardless to the other variable) on digestibility coefficients of cell wall constituents (% on DM basis, means ± SE).

Items	Crop residual type		Treatments		
	Corn stalks	Rice straw	Untreated	T1	T2
NDF	50.211A±0.70365	51.911A± 0.5604	49.700B ± 0.7410	51.917A ± 0.9234	51.567A ± 0.6364
ADF	48.760A ± 0.8112	48.793A ± 0.7724	47.430B ± 0.7653	48.700AB ± 0.9901	50.200A ± 0.5098
ADL	25.322B ± 0.6507	27.273A± 1.4682	22.810C ± 0.3874	25.550B + 1.4531	30.533A ± 0.7341
Cellulose	59.811B ± 1.2792	60.223A± 0.7746	57.567B ± 1.1062	59.917AB ± 0.9715	62.567A ± 0.8498
Hemicellulose	53.522B± 0.8231	55.437A ± 0.7688	54.672B ± 0.8137	53.750C + 0.9544	55.017A + 1.3595

A and B: Means in the same row different superscripts are significantly ($P \leq 0.01$) different.

Table (3): Effect of crop residual type and treatment on average feed units intake (means ± SE).

Items	Crop residual type		Treatment		
	Corn stalks	Rice straw	Untreated	T_1	T_2
DMI, CFM, g/h/day	443.311^A ± 0.7265	434.133^A ± 0.7218	320.300^C ± 1.1708	457.600^B ± 0.8111	538.267^A ± 0.5287
DMI, Roughage, g/h/day	592.478^B ± 0.4028	476.144^B ± 0.8653	584.383^B ± 1.0317	372.717^C ± 0.6687	645.833^A ± 2.3603
Total DM intake	1163.189^A ±0.5191	1131.878^B±0.4339	1281.783^A±1.1432	976.717^C ± 1.7776	1184.10^A ± 2.5472
g/Kg / $W^{0.75}$	58.056^A ± 1.7268	59.044^A ± 2.0136	62.383^A ± 0.6709	51.467^B ± 0.4461	61.800^A ± 1.1391
g/Kg / animal	21.344^A ± 0.5672	22.022^A ± 0.7327	22.800^A ± 0.3966	19.267^B ± 0.1202	22.983^A ± 0.4497
TDN, g/h/day	889.200^B ± 2.2531	949.356^A ± 0.3950	908.933^B ± 0.4655	851.050^C ± 2.4211	997.850^A ± 2.3762
SE, g/h/day	648.589^A ± 2.4658	677.544^A ± 0.4713	684.917^B ± 0.4129	553.483^C ± 2.8271	750.800^A ± 1.9356
DCP, g/h/day	118.700^B ± 2.4445	129.422^A ± 1.3955	148.017^B ± 0.8174	80.050^C ± 2.2394	144.117^B ± 0.5178
TDN / $W^{0.75}$	24.478^A ± 0.6823	25.389^A ± 1.0594	24.833^B ± 1.0689	22.667^C ± 0.6218	27.300^A ± 0.5045
SE / $W^{0.75}$	17.567^A ± 0.5716	18.133^A ± 1.2623	18.700^B ± 0.9803	14.783^C ± 0.7510	20.067^A ± 0.4223
DCP/$W^{0.75}$	32.228^B ± 2.5919	34.667^A ± 3.7443	40.450^A ± 1.9201	21.350^C ± 0.5358	38.542^B ± 1.5557
TDN/animal	16.651^B ± 0.7933	18.544^A ± 0.8594	16.450^B ± 1.3376	16.833^B ± 0.6253	19.510^A ± 0.7266
SE/animal	12.078^A ± 0.6904	13.211^A ± 0.9468	12.333^B ± 1.1547	10.950^C ± 0.6210	14.650^A ± 0.6096
DCP/animal	2.182^B ± 0.1623	2.517^A ± 0.2700	2.650^A ± 0.2362	1.592^B ± 0.0638	2.807^A ± 0.1428

A, B and C: Means in the same row with different superscripts are significantly ($P \leq 0.01$) different.
DMI = Dry matter intake CFM = Concentrate feed mixture

Table (4): Effect of crop residual type and treatment on average water intake under summer season conditions (means ± SE).

Items	Crop residual type		Treatment		
	Corn stalks	Rice straw	Untreated	T_1	T_2
Body weight, Kg	54.222^A ± 1.5709	51.333^B ± 0.7265	50.667^B ± 0.7600	51.333^B ± 0.9187	56.333^A ± 1.7823
$W^{0.82}$	26.414^A ± 0.6259	25.266^B ± 0.2931	24.997^B ± 0.3075	25.265^B ± 0.3703	27.258^A ± 0.7084
Water intake, l/head/day	3.968^A ± 0.2023	3.555^B ± 0.1044	3.481^B ± 0.1250	3.825^{AB} ± 0.2689	3.978^A ± 0.1900
ml/Kg BW	72.833^A ± 3.1180	69.232^B ± 1.7082	68.848^C ± 2.9332	74.217^A ± 4.1550	70.033^B ± 1.7944
Total DM intake, g/h/d	1162.522^A ±5.1693	1131.878^B ±4.3393	976.717^C ± 1.7776	1184.100^B ±2.5472	1280.783^A ±2.1295
ml/g DM intake	3.419^A ± 0.1146	3.277^A ± 0.1668	3.575^A ± 0.1575	3.368^A ± 0.2031	3.100^B ± 0.1122
ml/Kg $W^{0.82}$	150.056^A ±6.4329	140.633^B ±3.5264	139.500^C ± 5.7441	150.850^A ±8.8066	145.683^B ±4.3539
Urine excretion, ml/h/day	1235.611^A ±5.4502	1340.556^A ±6.5981	1328.333^A ±10.8015	1262.833^C ±7.1873	1273.083^B ±4.3499
% of water intake	31.307^B ± 0.7082	37.661^A ± 1.3173	37.973^A ± 2.1697	33.260^B ± 1.0727	32.218^C ± 1.3412

ml=milliliter $W^{0.82}$= Metabolic body mass A, B and C: Means in the same row with different superscripts are significantly ($P \leq 0.01$) different.

Table (5): Effect of crop residual type and treatment (regardless to the other variable) on nitrogen balance (means ± SE).

Items	Crop residual type		Treatment		
	Corn stalks	Rice straw	Untreated	T_1	T_2
N-intake (g/d)	$24.702^{A} \pm 2.1643$	$22.511^{B} \pm 1.7282$	$16.658^{C} \pm 0.2402$	$24.338^{B} \pm 0.8166$	$29.823^{A} \pm 0.9554$
N-excreted (g/d)					
Urine	$9.822^{A} \pm 1.2542$	$9.194^{A} \pm 1.1988$	$5.233^{C} \pm 0.1827$	$10.275^{B} \pm 0.3157$	$13.258^{A} \pm 0.3743$
Faces	$11.920^{A} \pm 0.5008$	$10.641^{B} \pm 0.4095$	$10.293^{B} \pm 0.1292$	$10.772^{B} \pm 0.5970$	$12.777^{A} \pm 0.4267$
Total	$21.742^{A} \pm 1.7453$	$19.835^{B} \pm 1.4362$	$15.285^{C} \pm 0.2695$	$21.047^{B} \pm 0.8406$	$26.035^{A} \pm 0.6710$
N-balance (g/d)	$2.960^{A} \pm 0.4576$	$2.676^{A} \pm 0.3650$	$1.373^{B} \pm 0.0811$	$3.292^{A} \pm 0.2098$	$3.788^{A} \pm 0.3650$
% of N-intake	$11.452^{A} \pm 0.9648$	$11.528^{A} \pm 1.1146$	$8.260^{C} \pm 0.5253$	$13.602^{A} \pm 1.0121$	$12.608^{B} \pm 0.8287$

A, B and C: Means in the same row with different superscripts are significantly ($P < 0.01$) different.

Table (6): Effect of crop residual type, treatment and time of sampling (regardless to the other variables) on rumen parameters of sheep (means ± SE).

Items	Crop residual type		Treatment			Time		
	Corn stalks	Rice straw	Untreated	T_1	T_2	0 hr	3 hr	6 hr
pH	$6.104^{A} \pm 0.112$	$6.096^{A} \pm 0.103$	$6.011^{B} \pm 0.104$	$6.133^{A} \pm 0.160$	$6.156^{A} \pm 0.126$	$6.500^{A} \pm 0.054$	$5.389^{B} \pm 0.039$	$6.411^{A} \pm 0.064$
NH_3-N, mg/dl	$23.480^{A} \pm 1.231$	$19.190^{B} \pm 0.986$	$17.539^{C} \pm 1.092$	$21.750^{B} \pm 1.304$	$24.706^{A} \pm 1.451$	$16.050^{C} \pm 0.952$	$27.056^{A} \pm 1.177$	$20.889^{B} \pm 0.807$
TVFA, m eq/dl	$17.989^{A} \pm 1.390$	$15.270^{B} \pm 1.311$	$16.306^{B} \pm 1.504$	$18.117^{A} \pm 1.815$	$15.467^{C} \pm 1.710$	$10.622^{C} \pm 0.382$	$25.361^{A} \pm 1.132$	$13.906^{B} \pm 0.475$
MP, mg/dl	$20.844^{A} \pm 1.291$	$19.596^{B} \pm 1.531$	$19.078^{B} \pm 1.691$	$21.161^{A} \pm 1.797$	$20.422^{A} \pm 1.746$	$13.917^{C} \pm 0.546$	$30.044^{A} \pm 0.383$	$16.700^{B} \pm 0.287$

pH = Negative power of hydrogen ions concentration TVFAs = Total volatile fatty acids NH_3-N = Ruminal ammonia M.P= Microbial protein
A,B and C: Means in the same row with different superscripts differ significantly ($P < 0.01$).

Table (7): Effect of crop residual type and treatment on some blood constituents (regardless to the other variable) of sheep at the end of the digestibility traits (means ± SE).

Items	Crop residual type		Treatment			
	Corn stalks	Rice straw	Untreated	T_1	T_2	Normal range *
Total protein, g/dl	$6.82^{A} \pm 0.311$	$6.64^{A} \pm 0.167$	$5.92^{C} \pm 0.135$	$6.92^{B} \pm 0.178$	$7.37^{A} \pm 0.182$	6.3 – 8.4
Albumin, g/dl	$3.87^{A} \pm 0.188$	$3.58^{B} \pm 0.141$	$3.25^{C} \pm 0.043$	$3.77^{B} \pm 0.186$	$4.17^{A} \pm 0.158$	3.5 – 5.5
Globulin, g/dl	$2.94^{B} \pm 0.131$	$3.07^{A} \pm 0.053$	$2.67^{B} \pm 0.109$	$3.15^{B} \pm 0.022$	$3.20^{B} \pm 0.058$	2.38 – 5.3
A/G ratio	$1.33^{A} \pm 0.029$	$1.18^{B} \pm 0.050$	$1.25^{A} \pm 0.053$	$1.20^{A} \pm 0.063$	$1.32^{A} \pm 0.058$	-
Urea, mg/dl	$31.60^{A} \pm 0.915$	$29.38^{B} \pm 0.950$	$27.05^{C} \pm 0.659$	$31.58^{B} \pm 0.266$	$32.83^{A} \pm 0.842$	10 – 50
Creatinine, mg/dl	$0.98^{A} \pm 0.018$	$0.97^{A} \pm 0.022$	$0.97^{A} \pm 0.029$	$0.97^{A} \pm 0.019$	$0.98^{A} \pm 0.027$	0.8 – 1.5
AST, u/l	$22.90^{A} \pm 0.555$	$23.99^{A} \pm 1.041$	$26.08^{A} \pm 0.982$	$21.70^{B} \pm 0.452$	$22.55^{B} \pm 0.433$	8 – 40
ALT, u/l	$10.57^{A} \pm 0.694$	$10.03^{A} \pm 0.369$	$11.47^{A} \pm 0.939$	$9.83^{A} \pm 0.223$	$9.60^{A} \pm 0.423$	5 – 30
Alkaline phosphatase, u/l	$25.14^{A} \pm 0.431$	$25.87^{A} \pm 0.279$	$25.70^{A} \pm 0.413$	$25.08^{A} \pm 0.658$	$25.73^{A} \pm 0.229$	9 – 35

A, B and C: Means in the same row with different superscripts are significantly ($P < 0.01$) different. * Kaneko (1989)