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Effect of Biological Treatments of Rice Straw on Growth Performance, Digestion and Economical Efficiency for Growing Calves

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Abstract: This study aimed to evaluate the effect of feeding rice straw treated biologically on body weight gain, nutrients digestibility and economical efficiency for growing calves. Chopped rice straw was treated with fungi (*Phanerochaete chrysoporium*) under aerobic condition 14 days as fermentation period. After this period, the treated rice straw was collected and sun dried. Sixteen growing calves were randomly divided into two equal groups (8 calves in each). The two groups were fed on concentrate feed mixture, (CFM) as a concentrate part at 2% of their body weight. The first group was fed on untreated rice straw at 1% of their body weight (R1), while the second group was fed on biological treated rice straw at the same rate (R2). The feeding trial lasted for 120 days. At the end of this period grab feces sample were taken for determine nutrients digestibility. The results indicated that, biological treated rice straw contained higher CP, EE and ash contents, while it contained lower OM, CF, NFE, NDF, ADF, ADL, hemicellulose and cellulose contents than untreated straw. Calves fed ration contained biological treated rice straw had significant ($P< 0.01$) higher all nutrients digestibility and nutritive value in terms of TDN and DCP values than calves fed untreated rice straw. Daily DM intake was no significant different for the two experimental rations, while the TDN and DCP intakes were significant ($P< 0.01$) increased for animals fed treated rice straw compared with those fed untreated rice straw. Average daily weight gain was insignificant increased for calves fed treated rice straw, Feed conversion was better for calves fed biological treated rice straw compared with those fed untreated one. Animals fed treated straw show better feed economic efficiency than animals fed untreated straw. It could be concluded that can be used biological treated straw in growing calves ration, whereas improved nutrients digestibility, body weight gain and economic efficiency.

Key words: Biological Treatment · Rice Straw · Chemical Composition · Nutrients Digestibility · Growth Performance and Economic Efficiency

INTRODUCTION

The shortage in animal feeds in Egypt necessitates that intense research efforts should be directed towards exploring the possibility of using new-nonconventional sources or agricultural by-products as animal feed and improving their nutritive values [1].

Cereal crops generate large amount of organic agricultural waste in many countries. Cereal straws have an economical value and their residues are utilized mainly in cattle production as feedstuff and / or as bedding [2]. In Egypt, there are about 30 million tons of agricultural residues available per year. Rice straw is a major crop residue in surplus amounts [3, 4].

Residues are burned or wasted and hence lead to environmental pollution and health hazards. The main factors limiting the utilization of crop residues are their low digestibility, low protein content and some time low palatability. Rice straw has always been used as ruminant feed, since its quantities increase every year. However, it has several nutritional limitations for ruminants, because it has a low crude protein (CP), high crude

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fiber (CF) content and low digestibility coefficients. Several experiments have been carried out on non-protein nitrogen treatments to increase its protein content [5- 9].

Locally produced feeds are not sufficient to meet the nutritional requirements of livestock in Egypt [10]. Encouraging results obtained from using by- products in animal diets could help in reducing the shortage of animal feeds and subsequently increase milk and meat production. However, the nutritive value of the agricultural by-products like rice straw can be enhanced through their biological treatment and hence they can play an important role to meet nutrient requirements of the animals and to avoid pollution resulting from chemical treatments.

The present study aimed to investigate the ability of biological treatment to improve the chemical composition and nutritive value as total residue and evaluate the effect of using untreated or treated rice straw on digestibility, growth performance and economic efficiency of growing calves.

MATERIALS AND METHODS

This study was carried out at the Nubaria Experimental Station, El-Hussein Village, Nubaria region, Behaira Governorate and on the Laboratories of Animal Production Department, National Research Center, Dokki, Giza, Egypt.

Crop Residues: Rice straw was chopped into 3-5 cm. The rice straw was strained until the moisture level reached 65-70 %, then incubated by fungi layer by layer in order and left 14 days under air temperature in shaded place, then dried also under air temperature for one week in sunny place.

Biological Treatment

Fungal Treatment: White rote (*Phanerochaete chrysoporium* NRRL-6361) was maintained on potato agar medium (PDA), grown at 28°C for 72 hrs, then stored at 4°C and recultivated every two months. Two different media were used to grow the fungus: a) Potato dextrose agar medium (PDA); Difco Manual [11] was used as a maintenance medium for fungal culture. It consists of (g/L): Potato extract (4.0), glucose (20.0) and agar (20.0) pH was adjusted to 5.6 before autoclaving at 121°C for 20 min. b) Nutrient glucose broth [12] was used to prepare the fungal inoculums of *Phanerochaete chrysoporium*. It consists of (g/L): Peptone (5.0), glucose (20.0), yeast extract (5.0) and beef extract (3.0). The pH was adjusted to 6.4 before autoclaving at 120 °C for 20 min.

Chemical Analysis: Proximate analysis for feed ingredients, faeces and urine was determined according to AOAC [13] methods. The cell wall constituents (neutral detergent fiber, NDF; acid detergent fiber, ADF and acid detergent lignin, ADL) were estimated according to the method of Goering and Van Soest [14]. Hemicellulose and cellulose values were calculated by difference.

Growth Trial: Sixteen growing Baladi calves were distributed into two similar groups (8 calves in each), according to their weight. Average initial live body weight was 222.56 ± 4.32 kg/head. The groups were fed at random the two respective rations in 2 meals/day (8 a.m. and 4 p.m.), in groups as follows: R1: CFM + untreated rice straw (Control), R2: Concentrate feed mixture (CFM) + treated rice straw with white rote fungi (*Phanerochaete chrysoporium* NRRL-6361) for 120 days. All calves were fed CFM and untreated or fungal treated rice straw (2% CFM and 1% rice straw of their live body weight). Animals were raised under hygienic and managerial conditions. Fresh water and mineral blocks were available at all times through the experimental period. The trial lasted for four months during which body weight changes and feed intake were recorded.

Digestibility Trial: At the end of feeding trial, four animals from each group were used to carry out two digestibility trials. A grab sample method was applied at which acid insoluble ash (AIA) was used as an internal marker according to Van Keulen and Young [15] for determining nutrients digestibility as to the following equation:

$$\text{Digestion coefficient of nutrient} = 100 - \left(\frac{100 \times \%\,\text{AIA in feeds} \times \%\,\text{Nutrient in feces}}{\%\,\text{AIA in feces} \times \%\,\text{nutrient in feeds}} \right)$$

Samples of feces were taken for five days from each animal and sprayed with 10% sulphuric acid and 10% formaldehyde solutions and dried at 60°C for 24 hrs. Samples were mixed and store for chemical analysis. Composite samples of feeds and feces were finely ground prior to analysis. The nutritive values expressed as the total digestible nutrient (TDN) and digestible crude protein (DCP) of the experimental rations were determined.

Statistical Analysis: Collected data for feeding and digestibility trials were subjected to statistical analysis as T-test according to SPSS [16]. Differences among means were examined using multiple range tests according to Duncan [17].

RESULTS AND DISCUSSION

Chemical Composition: Chemical composition of CFM and untreated or biological treated rice straw are presented in Table 1. The results showed that, the organic matter (OM), crude fiber (CF), nitrogen free extract (NFE), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose and hemicellulose contents of the rice straw treated with fungal were lower than untreated rice straw. This result may be due to the fungus depend on carbohydrates including soluble carbohydrate and crude fiber and its fraction as carbon source to produce CO_2 and energy and use this energy with nitrogen sources in the media to grow up and convert them to microbial protein. Moreover, crude protein (CP) and ash contents of treated rice straw were higher than untreated. The biological treatment increased crude protein from 3.20 to 11.62% for untreated and treated rice straw, respectively. The improvement of CP content could be attributed to fungus growth [9]. Dhanda *et al*. [18] found that crude protein content of spent straw increased from 3.42 to 6.19% with biological treatment. The biological treatment for rice straw reduced NDF, ADF, ADL, hemicellulose and cellulose compared with untreated rice straw. These results might be due to the breakdown of lignocelluloses bonds where the cellulose can be hydrolyzed by fungi [9, 19-21]. Baraghit *et al*. [22] reported that biological treatments with different fungal and bacteria strains decreased cell wall constituents of different crop residues. The results in the present study are in agreement with those reported by Shoukry [5], Larwance and Abada [23], Gupta and Langer [24], Gado [25], Khorshed [26], Abdul-Aziz *et al*. [27], Mahrous and Khorshed [28]and Abd El-Galil and Salem [29].

Digestibility Coefficients and Nutritive Value: Nutrient digestibility coefficients and nutritive values of the experimental rations are presented in Table 2. The biological treatments increased the values of nutrients digestion coefficients than those untreated rice straw. The results in this study showed the highest ($p<0.01$) digestion coefficients for all nutrients of rice straw treated with white rote fungi (*Phanerochaete chrysoporium*) compared with untreated rice straw. The improvement of nutrients digestibility reflected on the nutritive value of treated rice straw compared with untreated one. These remarkable improvements in all nutrients digestibility in ration contained fungal treated rice straw compared with untreated one, that could be attributed to the effect of fungal treatment by white rote fungi in up grading and positive alteration of the chemical composition of rice straw. These positive results could be also supported by the earlier investigations in using even raw rice straw in small or large ruminants rations, which recorded positive improving in nutrients digestibility and nutritive value [9, 28,30].

Table 1: Chemical composition and cell wall constituents of the concentrate feed mixture, untreated and treated rice straw.

Item	CFM	URS	TRS
Dry matter (DM), %	93.52	91.13	93.38
Chemical composition (%) on DM basis:			
Organic matter (OM)	87.51	83.43	79.19
Crude protein CP)	15.30	3.20	11.62
Crude fiber (CF)	23.41	38.33	35.17
Ether extract (EE)	3.01	1.07	1.30
Nitrogen free extract (NFE)	45.79	40.83	31.10
Ash	12.49	16.57	20.81
Cell wall constituents (%) on DM basis:			
NDF	36.33	67.73	61.23
ADF	19.73	46.77	42.17
ADL	5.55	16.89	14.16
Hemicellulose	16.60	20.96	19.06
Cellulose	14.18	29.88	28.01

CFM: Concentrate feed mixture chemicellulose = NDF-ADF Cellulose = ADF-ADL

URS: untreated rice straw. TRS: treated rice straw.

Table 2: Effect of biological treatment on apparent nutrients digestibility and nutritive value for calves fed untreated and treated rice straw.

	Experimental rations		
Item	R1	R2	Sig.
Nutrients digestibility (%):			
DM	60.36±0.31	67.42±0.21	**
OM	61.35±0.28	68.46±0.34	**
CP	63.34±0.21	69.41±0.21	**
CF	58.07±0.31	63.53±0.48	**
EE	62.06±0.32	67.01±0.60	**
NFE	61.48±0.40	65.76±0.38	**
NDF	52.50±0.24	64.50±0.32	**
ADF	45.77±0.25	62.12±0.65	**
ADL	21.78±0.15	46.03±0.24	**
Cellulose	53.41±0.20	67.44±0.56	**
Hemicellulose	61.05±0.12	69.08±0.35	**
Nutritive value (%):			
TDN	54.27±0.20	57.65±0.27	**
DCP	7.14±0.02	9.77±0.68	**

** Means in the same row are significant by different at (P<0.01).

Table 3: Dry matter, TDN and DCP intake of growing calves fed untreated and biological treated rice straw.

	Experimental rations		
Item	R1	R2	Sig.
Av. Body weight (kg)[1]	298.75±3.16	303.31±6.62	NS
Metabolic body size [2]	71.86±o.60	72.66±1.68	NS
Dry matter intake (kg/day) of:			
CFM	5.97 ±0.07	6.07±0.13	NS
Roughage	2.99±0.03	3.03±0.07	NS
Total DM intake	8.96±0.10	9.10±0.20	NS
Concentrate (%)	66.63	66.70	-
Roughage (%)	33.37	33.30	-
Feed intake as:			
Dry matter			
Kg/day	8.96	9.10	-
g/kgw$^{0.75}$	124.69	125.21	-
Kg/100 kg BW	3.00	3.00	-
TDN			
Kg/day	4.86±0.05	5.25±0.11	**
g/kgw$^{0.75}$	67.63±0.19	72.10±0.39	**
Kg/100 kg BW	1.63	1.73	**
DCP			
g/day	639.74±7.09	889.07±19.39	**
g/kgw$^{0.75}$	8.90±o.o2	12.23±0.11	**
g/100 kg BW	214.14	293.12	**

1: Av. body weight (kg) = Initial weight +final weight /2.

2: Metabolic body size = kgw$^{0.75}$.

NS: Non significant.

** Means in the same row are significant by different at (P<0.01).

Table 4: Effect of biological treatment on growth performance for calves fed untreated and treated rice straw.

	Experimental rations		
Item	R1	R2	Sig.
No. of animals	8	8	
Experimental period (day)	120	120	
Initial body weight (kg)	222,38±4.36	222.75±10.51	NS
Final body weight (kg)	373.88±4.40	382.74±7.23	NS
Total gain (kg/head/period)	151.50±5.74	159.99±12.25	NS
Average daily gain (kg/h/d)	1.262±0.05	1.333±0.10	NS
Relative daily gain efficiency	100	105.63	
DM intake (kg/h/d):			
CFM	5.97±0.07	6.07±0.13	NS
URS or TRS	2.99±0.03	3.03±0.07	NS
Total DM intake	8.96±0.10	9.10±0.20	NS
Feed conversion (kg feed/kg gain)	7.16±0.25	6.89±0.78	NS

NS: Non significant.

Table 5: Effect of fungal treatment on economic evaluation of the experimental rations for growth performance of calves.

Item	URS	TRS
No. of animals	8	8
Feeding period (day)	120	120
Purchase cost (L.E.*/head)[1]	6949.38	6960.94
Feed cost (L.E./head)[2]	2032.08	2083.08
Management cost (L.E./head)[3]	720	720
Total cost (L.E./head)[4]	9701.46	9764.02
Selling income(L.E./head)[5]	10842.57	11099.45
Net revenue (L.E./head)[6]	1141.11	1335.44
Economic feed efficiency (%)[7]	11.76	13.68
Relative economic efficiency (%)[8]	100	116

* L.E.= Egyptian pound that equal 0.1399 US$

1: Body weight X price of one kg (31.25 L.E.).

2: Calculated according to local price (2500, 300and 350 L.E. /ton for concentrate feed mixture, untreated rice straw and treated rice straw.

3: Include operation and medicinal cost. 4: Include the fixed management, purchase cost and feed cost.

5: Body weight X price of one kg at selling (29.oo L.E.).

6: Selling income - total cost. 7: Net revenue / total cost X 100.

8: Economic efficiency for treatment / economic efficiency for control assuming that relative economical efficiency of the control group equal 100.

The cell wall constituents (NDF, ADF, ADL, hemicellulose and cellulose) coefficients digestion recorded for treated rice straw were significantly higher ($P<0.01$) than those obtained for untreated one. The results agreed well with Deraz and Ismail [20] and El-Ashry *et al*. [31] who reported that the biological treatments loosening lignocelluletic bonds and soluble some of the hemicelluloses contents. These results were in agreement with Mahrous and Khorshed [28] and Mahrous *et al*. [32].

Daily Feed Intake: Daily dry matter and nutrients intake by animals are presented in Table 3.The results revealed that the total dry matter intake as concentrate and roughage were not significantly different between treatment and control. The total digestible nutrient intake as (TDN) kg/ day, g/kg $w^{0,75}$ and kg/100 kg BW and digestible crude protein intake (DCP) as g/day, g/kg$w^{0.75}$ and g/100 kg BW for group fed treated rice straw were higher than group fed untreated one. The increasing in intakes of TDN and DCP may be due to increasing in all nutrients digestibility and cell wall constituents and feeding value as shown in Table 2. These results are agreement with El-Ashry *et al*. [9], Mahrous and Khorshed [28] and Mahrous *et al*. [32].

Growth Performance and Economical Evaluation: The average daily body gain (ADG) and feed conversion of the two experimental groups are presented in Table 4. The results revealed that the average daily weight

gain were insignificant (p>0.05) higher for group fed biological treated than group fed untreated rice straw. The DMI as (kg/h/d) of calves was insignificant higher for calves fed treated than those fed untreated rice straw (8.96 vs. 9.10 kg/h/d), respectively. The feed conversion (kg DM/kg gain) showed that the fungus treatment of rice straw recorded the best value (6.87) compared to untreated rice straw (7.16). These results were agreement with Mahrous and Khorshed [28], Mohamed *et al*. [33], Mahrous and Abou Ammou [34] who indicated that the feed conversion of treated rice straw was better compared with untreated one.

In this study the overall obtained results in revealed that the biological treatment of rice straw by fungus increased protein content, protein and fiber fractions digestibility. The recycling of agriculture wastes is important to raise its nutritional value and can be used in the ruminants feeding. Biological treatments can utilize lignin along with cellulose and other components of the substrate. These organisms grow slowly and degrade the structural carbohydrates of crop residues.

Based upon the difference in both growth rate and feeding cost per animal, the economical feed efficiency as affected by using untreated and treated rice straw could be calculated (Table 5). Total feed cost was increased for treated rice straw (9764.02 L.E./head) compared with untreated rice straw (9701.46 L.E./head), this result due to the cost of biological treatment for rice straw (50 L.E./ton). The net revenue (L.E./head) was higher for treated rice straw (1333.44 L.E./head) compared with untreated (1141.11 L.E./head). This increasing of net revenue was due to increasing the average daily gain for group fed treated rice straw than the group fed untreated (1.333 vs. 1.262 kg/h/d), respectively. On the other hand, the economic feed efficiency for animals fed treated rice straw was higher (13.68 %) than those fed untreated rice straw (11.76 %), similar trend was noticed for relative economic efficiency values, the value for animals fed biological treated rice straw was 116 %, this show that the improvement in economic efficiency was 16 % compared with untreated.

CONCLUSION

From the previous results it could be concluded that the biological treatment by fungi could be successfully used to enrich rice straw with protein, improve nutrients digestibility and nutritive value of rations those containing fungi treated rice straw and subsequently improve calves performance and economical feed efficiency.

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