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EFFECT OF BIOLOGICAL TREATMENTS ON CHEMICAL COMPOSITION, *IN VITRO* AND *IN VIVO* NUTRIENTS DIGESTIBILITIES OF POOR QUALITY ROUGHAGES

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SUMMARY

Four low quality roughages, namely banana waste, corn stalks, rice straw and wheat straw, were subjected to biological treatment under solid state fermentation by *Trichoderma viride* (F-516), *Penicillium funiculosium* (629) and *Saccharomyces cerevisiae* (AFZ-98). The biological treatments resulted in significant ($P<0.01$) increases in dry matter and crude protein contents as well as in vitro dry matter and organic matter disappearances (IVDMD and IVOMD). On the other hand, a significant decrease in crude fiber (CF) content ($P<0.01$) was recorded. Fungal treatments decreased hemicellulose and cellulose contents in all wastes used ($P<0.01$). The biologically treated banana waste achieved the highest values for organic matter (OM), ether extract (EE) and nitrogen free extract (NFE) contents as well as IVDMD and IVOMD. Thus, eight lactating Balady goats were divided into four groups (two animals each) in a 4x4 Latin square design, to study the effect of the experimental treatments namely: Control (C), *Trichoderma viride (F-516)* (T_1), *Penicillium funiculosium (629)* (T_2) and *Saccharomyces cerevisiae (AFZ-98)* (T_3), on the nutrients digestibilities in banana waste. The control, fungal and yeast culture treated banana waste were adjusted with media to approximately 60% moisture and were packed in airtight polyethylene bags. The bags were sealed and incubated at room temperature (27-30 ^{0}C) for 21 days. Animals were fed the experimental diets at 30:70 treated banana wastes: concentrate ratio. The results revealed that all biological treatments significantly ($P<0.01$) increased OM, CF, NFE, ADF, hemicellulose and cellulose digestibilities. Goats fed, biologically treated banana waste showed significant increases ($P<0.05$) of CP, EE and NDF digestibilities. Biological treatment with *P. funiculosium* (629) achieved the highest improvements.

Keywords: *biological treatments, low quality roughages, fiber fraction, in vitro and in vivo digestibility.*

INTRODUCTION

In Egypt, there is a wide gap between the available feedstuffs and farm animal requirements. This was estimated as a shortage of 3.1 million tons of TDN per year (Abou-Akkada, 1988). Although 13.7 to 15.2 million tons of agricultural cellulosic wastes are produced in Egypt annually, only 4.0 to 4.3 million tons of crop residues are used for ruminant feeding (Hathout and El-Nouby, 1990). Approximately two thirds of the crop residues are burned or wasted hence contributing to environmental pollution and subsequent health hazards. Wheat and rice straws are the main roughages used in animal feeding. Due to their continuously increasing prices, attempts to use other new sources of roughages such as banana wastes were conducted by many workers (El-Kady, 1997 and Khattab, *et al.* 2000). Biological treatments using *Trichoderma viride* (Abdul-Aziz, *et al.* 1997 and Khorshid, 2000) and *Penicillium funiculosium* (Abdelgadir, *et al.* 1997 and El-Ashry, et al. 1997) or fibrolytic enzymes (David, et al. 1999 and Yang, et al. 1999) were tested to improve the nutritive value and digestibility of poor quality roughages. Yeast treatment was used to improve rumen digestibility of nutrients especially crude fiber for elevation, also, of rumen fermentation and more activation of rumen microorganisms (Offer and Cruive 1991and Dawson, 1992).

The objectives of this study were to investigate the ability of some biological treatments (using fungi or yeast) to improve chemical composition, nutritive value and in vitro and in vivo digestibility. The poor quality roughages used were: dried banana wastes (BW), rice straw (RS), wheat straw (WS) and corn stalks (CS). Two fungi {*Trichoderma viride F-516* (TV) and *Penicillium funiculosium (629)* (PF)} and yeast culture {*Saccharomyces cerevisiae AFZ-98* (SC)} were used for biological treatment of the experimental roughages.

MATERIALS AND METHODS

Microorganisms:

Trichoderma viride F-516, *Penicillium funiculosium* (629) and *Saccharomyces cerevisiae* (AFZ-98) were obtained from the Microbial Chemistry Department, National Research Center, Dokki, Cairo, Egypt. The microorganisms were maintained on agar medium composed of (g/l) yeast extract, 3.0; malt extract, 30; peptone, 5.0; sucrose 20 and agar 20.

Agricultural wastes:

Banana leaves (BW), rice straw (RS), wheat straw (WS) and corn stalks (CS) were collected from local Egyptian fields after harvesting. The air-dried wastes were shopped to 1-2 cm then packed till used. Chemical composition of experimental roughages are shown in Table (1)

Mycotoxins test:

Thin layer chromatography for detection of mycotoxins, if any in the treated wastes, was applied according to the methods described by Trank and Chu (1971), A.O.A.C. (1980), Northolt, *et al.* (1979), Wagener, et al. (1980) and Hou, *et al* (1971). Biological assay used was according to the method of Scott and Bullerman (1975) and described by Fadel, *et al.* (1992).

Preparation of fungal inoculum:

Three days old slants cultures of *Trichoderma viride* F-516 or *Penicillium funiculosium* (629) were individually crushed into flasks containing 20 ml of sterilized tap water. The fungal spores suspensions were used as inoculum at 10% (v/w) to inoculate 500 ml capacity flasks containing 20 g of the ground waste moistened at a solid : liquid ratio of 1:2 with basal medium composed of (g/l) sugar cane-molasses, 40; urea, 2.0; potassium dihydrogen phosphate, 2.0 and magnesium sulphate, 0.3. The inoculated flasks were incubated at $30 \pm 1^{0}C$ for 72 h under static solid state fermentation system.

Preparation of fungal treatments:

The above-prepared inocula were employed to inoculate 200 g of waste under study moistened by the above basal medium at a solid: liquid ratio of 1:2 and packed in polyethylene bags (40 x 60 cm). The inoculated bags were incubated under static conditions for 7 days at 30 ± 2 ^{0}C. At the end of incubation period such bags were opened and oven dried at 70 ^{0}C for chemical analysis.

Scaling up the fungal treatments:

The above fermented bags were employed to inoculate polyethylene bags (150 x 225 cm) containing 10 kg of ground waste moistened with the basal medium at a solid: liquid ratio of 1:2. The bags were incubated in a 3x3 meters room maintained at 27-30 ^{0}C for 21days. After the incubation period the fermented wastes were air-dried to 6-8% moisture then packed and stored until fed to lactating goats.

Yeast inoculum preparation and treatment:

A loop of 48 h old slants culture of *S. cerevisiae* AFZ-98 was used to inoculate each conical flask containing 100 ml sterilized basal medium. The flasks were incubated statically for 48 h. The growing yeast culture was used as inoculum at 10% (v/w) to inoculate 200 g of waste under study moistened by the basal medium at a solid : liquid ratio of 1:2, packed in polyethylene bags (40 x 60 cm) then incubated for 5 days at 30 ^{0}C. The treatment was scaled up similar to fungal treatments for 7 days.

In vitro test:

The in vitro DM and OM disappearances (IVDMD and IVOMD) were done for samples of different treatments (control, T_1, T_2 and T_3) according to Tilley and Terry (1963), modified by Norris (1976). Rumen liquor was collected, two hours post feeding, from three male goats maintained on good quality berseem hay. Collected rumen liquid was kept warm in plastic jug (35-37 ^{0}C), strained through two layers of cheese cloth and mixed with urea-buffer solution under the lab. condition for *in vitro* studies.

Digestibility trials:

Eight lactating Balady goats weighing 23-27 kg live weight, during the first week of lactation, were used in a digestibility trial. The animals were randomly assigned among four experimental treatments (two animals each) using 4x4 Latin square design. The total period of this trial was 120 days divided into four experimental periods each of 30 days. All animals were fed on 70% concentrate feed mixture (CFM) and 30% dried banana waste soaked with water only (Control), *T. viride* (T_1), *P. funiculosium* (T_2) or *S. cerevisiae* (T_3). The CFM consisted of 25% undecorticated cotton seed meal, 35% yellow corn, 20% wheat bran, 15% rice bran, 3% limestone, 1.2% salt and 0.8% minerals. Daily rations were offered individually in two equal portions at 8.00 a.m. and 3.00 p.m. Amount of daily feeds were calculated for each animal's requirement form starch equivalent (SE) and digestible crude protein (DCP) according to ARC (1983). Water was available at all times. Grab sample method was used and silica as internal marker, was applied for determining the digestibility. Feces grab samples were collected manually at 8.00 a.m. for three successive days from each animal. Solution of 10% H_2SO_4 was added to the representative samples then dried in an oven at 70°C for 24 h. The dried feces samples from each animal were mixed and stored at -18^0C for chemical analysis. The digestibility coefficient was calculated according to the following formula (according to Gallups *et al.*, 1945 and Forbes and Garrigus, 1948) :

$$\text{Digestibility} = 100 - \left[100 \times \frac{\text{indicator in feed \%}}{\text{indicator in feces \%}} \times \frac{\text{nutrient in feces \%}}{\text{nutrient in feed \%}}\right]$$

Chemical composition of dietary ingredients (CFM and dried banana waste subjected to different treatments) are shown in Table (2)

Chemical analysis:

The oven-dried samples at 70 °C were ground comminuted and well mixed. Dry matter (DM), ash, organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and nitrogen free extract (NFE) were determined according to A.O.A.C (1995). Fiber fractions were determined according to Goering and Van Soest (1970).

Statistical analysis:

The data were analyzed according to statistical analysis system (SAS, 1989). Duncan's new multiple range was applied to separate between significant means.

Data of chemical composition of treated residues were analyzed according to two way classification design where the model was;

$$Y_{ijk} = \mu + T_i + R_j + E_{ijk}$$

Where, Y expressed the every observation of the j^{th}-roughages treated with i^{th} treatment, T (1-4) expressed the treatment effect, R (1-4) expressed the residues effect, and E expressed the experimental error.

Data of digestibility coefficients, feed efficiency and blood parameters were analyzed according to 4x4 Latin square design, where the model was;

$$Y_{ijkl} = \mu + T_i + P_j + A_k + E_{ijkl}$$

Where, Y expressed the every observation of the k^{th} animal in the j^{th} period given i^{th} treatment, T (1-4) expressed the treatment effect, P (1-4) expressed the periods effect A (1-16) expressed the animals effect and E expressed the experimental error.

RESULTS AND DISCUSSION

Chemical composition of wastes:

Table (1) shows that there were differences in chemical composition among the tested wastes. Banana waste had the highest value of OM, CP, EE, NFE and hemicellulose. Corn stalks had the highest percent of DM and ash. Wheat straw contained the highest levels of CF and cellulose. Rice straw contained the highest levels of lignin. While banana waste contained the lowest amounts of ash and CF. Wheat straw has lowest contents of NFE, hemicellulose and lignin. Rice straw contained the lowest CP percent.

Effect of biological treatments on the chemical composition, IVDMD and IVOMD of the roughages:

Tables (3-6) show the effect of biological treatments on the chemical composition, IVDMD and IVOMD of banana leaves, rice straw, wheat straw and corn stalks as a results of its biological treatment with *Trichoderma viride* (F-516) (T_1), *Penicillium funiculosium* (629) (T_2) or *Saccharomyces cerevisiae* (AFZ-98) (T_3). The biological treatments increased DM, CP and ash contents for all treated wastes, while OM and CF were decreased. These decreases were affected by both the fungus and the yeast treatments. The recovered fermented wastes were higher when rice straw and corn stalks were treated with *T. viride* (F-516), whereas the recovered fermented waste were higher when banana waste and wheat straw were treated with *P. funiculosium (625).* Treatment with *S. cerevisiae* (AFZ-98) resulted in the highest increase in dry matter for all treatments. The crude protein was improved by fungal biological treatments than by yeast. The increases in crude protein were 16.39, 11.48,13.34 and

Table (1): Chemical composition of the experimental materials (on DM basis).

Items	BW	WS	RS	CS
DM	93.62	93.27	93.39	93.72
OM	87.00	86.38	86.77	82.10
Ash	13.00	13.62	13.23	17.90
EE	6.11	5.34	4.55	3.40
CP	5.45	4.00	3.96	4.53
CF	29.3	39.40	35.50	32.70
NFE	46.14	37.64	42.76	41.47
Cellulose	32.30	38.80	42.00	31.60
Hemicellulose	29.87	17.14	23.00	29.11
Lignin	10.38	7.17	12.06	9.55

BW= banana wastes; WS= wheat straw; RS= rice straw; CS= corn stalks.

Table (2): Chemical composition of dietary ingredients (CFM and dried banana wastes subjected to different treatments) (on DM basis).

	CFM	Dried banana wastes			
		Control (C)	TV (T1)	PF (T2)	SC (T3)
Chemical composition:					
DM	90.93	93.62	96.39	97.18	96.97
OM	92.01	87.0	85.64	86.39	84.52
Ash	7.99	13.0	14.36	13.61	15.48
TP	15.58	5.45	7.15	7.39	7.40
EE	4.21	6.11	6.06	6.66	5.37
CF	12.48	29.3	26.82	27.86	28.46
NFE	67.73	46.14	45.61	44.48	43.29
Fiber fractions:					
NDF	30.65	73.72	67.80	66.90	58.16
ADL	7.56	11.55	8.08	9.81	9.80
Hemicellulose	13.09	29.87	22.47	21.78	14.34
Cellulose	10.0	32.30	27.25	30.31	34.02

Control: Dried banana waste (BW) fermented with water only. TV: Dried BW fermented with Trichoderma viride. PF: Dried BW fermented with Penicillium funiculosium. SC: Dried BW fermented with Saccharomyces cerevisiae.

Table (3): Chemical composition, IVDMD and IVOMD of banana waste as affected by different biological treatments for 21 days under solid state fermentation.

Items	Control	T. viride (F-516)	P. funiculosium (629)	S. cerevisiae (AFZ-98)	± SE
DM	93.02^{B}	96.39^{A}	97.18^{A}	96.97^{A}	0.54**
OM	87.0	85.64	86.39	84.52	0.83^{ns}
CP	5.45^{Bb}	13.15^{Aa}	16.39^{Aa}	7.40^{ABa}	0.47**
CF	29.30^{Aa}	26.82^{Bb}	27.86^{Abb}	28.46^{ABb}	0.42**
Ash	13.0	14.36	13.61	15.48	0.53^{ns}
EE	6.11	6.06	6.66	5.37	0.26^{ns}
NFE	46.14	45.61	44.48	43.29	0.63^{ns}
NDF	73.72	67.80	66.90	58.16	3.21^{ns}
ADF	43.85^{A}	35.33^{B}	45.12^{A}	43.82^{A}	2.02**
Hemicellulose	29.87	22.47	21.78	29.34	3.17^{ns}
Cellulose	32.30^{A}	27.26^{B}	30.31^{AB}	32.03^{A}	1.45**
IVDMD	52.84^{B}	59.12^{A}	60.24^{A}	61.96^{A}	2.03**
IVOMD	54.84^{Bb}	59.14^{ABa}	61.80^{Aba}	63.99^{Aa}	2.12**

**($P<0.01$), ^{ns}not significant ($P>0.05$), SE = standard error.

- Significant differences {($P<0.05$), small letter} between means, at the same row, are indicated by dissimilar superscripts

Table (4): Chemical composition, IVDMD and IVOMD of corn stalks as affected by different biological treatments for 21 days under solid state fermentation.

Items	Control	T. viride (F-516)	P. funiculosium (629)	S. cerevisiae (AFZ-98)	± SE
DM	93.62^{B}	96.39^{A}	97.18^{A}	96.97^{A}	0.62**
OM	82.10	83.23	82.91	82.74	0.34^{ns}
CP	4.53^{Bb}	10.64^{Aa}	11.48^{Aa}	6.55^{ABa}	0.30**
CF	32.70^{Aa}	29.16^{Bb}	30.31^{Abb}	30.22^{Abb}	0.55**
Ash	17.90	18.77	18.09	18.26	0.24^{ns}
EE	3.40	4.53	4.87	4.26	0.31^{ns}
NFE	41.47	43.96	42.25	43.71	0.59^{ns}
NDF	72.47	68.28	66.30	73.33	1.78^{ns}
ADF	43.36^{B}	43.63^{B}	42.13^{B}	48.29^{A}	1.35**
Hemicellulose	29.11	23.65	24.17	29.04	1.24^{ns}
Cellulose	39.60^{A}	32.20^{B}	32.31^{B}	38.39^{A}	1.18**
IVDMD	37.70^{B}	48.28^{A}	50.24^{A}	51.62^{A}	2.16**
IVOMD	46.08^{B}	58.74^{A}	56.20^{A}	60.0^{A}	3.16**

**($P<0.01$), ^{ns}not significant ($P>0.05$), SE = standard error.

- Significant differences {($P<0.05$), small letter} between means, at the same row, are indicated by dissimilar superscripts

Table (5): Chemical composition, IVDMD and IVOMD of rice straw as affected by different biological treatments for 21 days under solid state fermentation.

Items	Control	T. viride (F-516)	P. funiculosium (629)	S. cerevisiae (AFZ-98)	± SE
DM	93.50^{B}	96.55^{A}	96.92^{A}	96.42^{A}	0.21^{**}
OM	86.38	84.36	84.18	83.51	0.61^{ns}
CP	4.00^{B}	12.75^{A}	13.34^{A}	5.6^{B}	0.61^{**}
CF	39.90^{A}	34.0^{B}	34.18^{B}	34.93^{B}	1.27^{**}
Ash	13.62	15.14	15.82	16.49	0.61^{ns}
EE	5.34	4.21	4.37	3.77	0.33^{ns}
NFE	37.64	39.90	39.29	39.21	0.48^{ns}
NDF	66.4	64.27	63.3	66.58	0.81^{ns}
ADF	41.26^{B}	48.32^{A}	48.22^{A}	52.46^{A}	0.99^{**}
Hemicellulose	27.14	19.95	18.80	26.90	3.29^{ns}
Cellulose	38.80^{A}	30.77^{B}	30.73^{B}	39.1^{A}	0.95^{**}
IVDMD	48.53^{Bc}	57.29^{Aa}	59.62^{Aa}	54.25^{ABb}	1.84^{**}
IVOMD	53.60^{Bb}	60.42^{Aa}	57.95^{Abab}	59.0^{Aa}	1.47^{**}

$^{**}(P<0.01)$, ^{ns}not significant $(P>0.05)$, SE = standard error.

- Significant differences {$(P<0.05)$, small letter} between means, at the same row, are indicated by dissimilar superscripts

Table (6): Chemical composition, IVDMD and IVOMD of wheat straw as affected by different biological treatments for 21 days under solid state fermentation.

Items	Control	T. viride (F-516)	P. funiculosium (629)	S. cerevisiae (AFZ-98)	± SE
DM	93.39^{B}	96.89^{A}	96.36^{A}	95.96^{A}	0.58^{**}
OM	86.77	84.24	84.46	85.50	0.78^{ns}
CP	3.96^{B}	12.66^{A}	14.77^{A}	5.83^{B}	0.42^{**}
CF	35.50^{A}	34.60^{B}	34.11^{B}	35.93^{A}	0.21^{**}
Ash	13.23	15.76	15.54	14.50	0.88^{ns}
EE	4.55	3.19	3.33	4.70	0.40^{ns}
NFE	42.26	40.73	41.25	40.05	0.58^{ns}
NDF	73.35	68.36	63.21	78.52	2.45^{ns}
ADF	50.35^{Abb}	47.77^{Bb}	48.03^{Bb}	55.87^{Aa}	1.88^{**}
Hemicellulose	23.0	20.59	20.18	22.95	0.71^{ns}
Cellulose	42.0^{Aa}	36.87^{Bb}	38.41^{Abb}	42.97^{Aa}	1.45^{**}
IVDMD	38.76^{B}	44.93^{A}	44.14^{A}	45.83^{A}	2.04^{**}
IVOMD	39.78^{Cc}	45.0^{Bb}	46.42^{Abb}	53.26^{Aa}	2.27^{**}

$^{**}(P<0.01)$, ^{ns}not significant $(P>0.05)$, SE = standard error.

- Significant differences {$(P<0.05)$, small letter} between means, at the same row, are indicated by dissimilar superscripts

14.77 for BW, CS, RS and WS, respectively, when treated with *P. funiculosium (625)* as well as 13.15, 10. 64, 12.75 and 12. 66 for treatment by *T. viride*. On the other hand, the protein contents were 7.40, 6.55, 5. 60 and 5.83 in BW, CS, RS and WS treated with *S. cerevisiae*, respectively. Hemicellulose, cellulose and CF were decreased significantly ($P<0.01$) by fungal treatments. The hemicelluloses were reduced from 27.14% in the original rice straw to 19.95 and 18.80% in the fermented product by *T. viride* (F-516) *and P. funiculosium (629)*, respectively, (Table 5) and from 29.87% in the original banana waste to 22.47 and 21.78% in treated product with *T. viride* (F-516) *and P. funiculosium (625)*, respectively (Table 3). The product reduction in cellulose content was less than that of hemicellulose as it ranged between 6–9%, and the highest reduction was achieved in rice straw by fungal treatments. The ash content increased in treated substrates and the increases were higher in fungal treated wastes than those treated with yeast due to the reduction in organic matter.

The data presented in Tables (3-6) revealed significant improvement ($P<0.05$) in both IVDMD and IVOMD for all biological treated wastes. More improvements were achieved by yeast treatment for all tested wastes. IVDMD and IVOMD for BW and WS gave better results than CS and RS when treated with *P. funiculosium (625)* in contrast to treatment with *T. viride* (F-516).

The obtained results revealed the importance of biological treatments in recycling the low quality roughages to upgrade their nutritional values. The reduction in OM, CF, hemicellulose and cellulose for the fungal treated residues as well as the increase in CP were natural results for biotransformation of the treated wastes through enzymatic systems which have the ability to hydrolyze biopolymeres, namely, cellulose and hemicellulose to their monomers glucose and xylose which can be assimilated by the fungus to yield biomass rich in protein (Wood, 1985). The enzymes responsible for the above actions are cellulases (endoglucanase, exoglucanase and β-glucosidase) and xylanase. Also the fungi have a role in degrading the linkage in plant cells found between lignin and cellulose or hemicellulose (Wieland, 1988). Fungal species, type of waste, and culture conditions are criteria for the success of roughages biological treatments (Khorshed, 2000). *Trichoderma sp.* and *Penicillium sp.* were functioned for microbial protein production, cellulases and xylanase when cultivated on agricultural wastes (Fadel, 1983, Fadel *et al.* 1992 and Fadel, 2001). It is well established now that biological treatment of straw and other fibrous roughages result usually in marked increases in their nitrogen (crude protein) content when the treatment conditions were appropriate (Zadrazil, 1984). The crude protein of wheat straw increased significantly ($P<0.01$) by fungal treatment when treated to be 23. 2%. NDF, ADF, ADL and hemicellulose were reduced by 19.2, 15.3, 52.6 and 41.2%, respectively, when fermented with *T. viride* (Chawal and Kundu, 1987). On the other hand , the cellulose was reduced by 12% and lignin was increased by 8% when wheat straw was biologically treated by *T. viride* (Larwence and Abada, 1987). Chopped rice straw treated with *T. viride* or with a mixed culture of *T. viride* and *S. cerevisiae* resulted in significant decrease ($P<0.05$) in CF by 13. 6 and 12.1% respectively. Also, cellulose and hemicellulose were significantly decreased ($P<0.01$), whereas CP was significantly ($P<0.05$) increased (Abdul-Aziz *et al.*, 1997).

Effect of biological treatments of banana waste on the improvement in nutrient digestibilities coefficient of lactating goats:

Table (7) shows that nutrient digestibility coefficient and nutritive values for all treatments. The biological treatments increased ($P<0.01$ or $P<0.05$) the values of nutrient digestibility coefficients than there in control. Rations treated with fungal treatments (T_1 and T_2) showed higher ($P<0.01$) digestion coefficient values for all nutrients than yeast treatment (T_3), however, control recorded the lowest values of nutrient digestibilities. These results are agreement with those obtained by El-Ashry *et al.*, (1997) (with fungal treated rice straw and corn stalks) and Khorshed (2000) (with fungal or yeast treated rice straw, wheat straw, cotton stalks and corn stalks).

Calculating the improvement as percentages in nutrients digestibility of rations containing biologically treated dried banana wastes are shown in Table (8). Results show that all biological treatments (T_1, T_2 and T_3) had higher effect on improving nutrient digestibility. It is of interest to note that T_2 (*P. funiculusms*) was superior to all treatments in improving all nutrients followed by T_1 (*T. viride*) and then T_3 (*S. cerevisiae*). White rot fungi exhibited promising properties for the decomposition of lignin-cellulose containing materials and for increasing the availability of carbohydrates and production of fungal protein. So, the feed value of treated residues was increased. The increase in digestibility of EE and cellulose after the biological treatments can be considered as a consequence of the increased availability of these materials due to fungal attaches on the lignin. White rot fungi are able to increase the digestibility of plant residues without chemical and physical pretreatment through selective lignin degradation (Zadrazil, 1984). There was no evidence to show that white rot fungi can supply stimulatory factors to rumen microbes, therefor, its effect could have been participate cellulolysis. However, yeast is not cellulolytic. Chandeman and Offer (1990) suggested a possible explanation for the improvement in nutrient digestibility as NDF digestibility that yeast (*S. cerevisiae*) supplied stimulatory growth factors such as the B vitamins and / or iso-fatty acids to rumen cellulolytic microbes by improving the substances derived from monosaccharide degradation, especially starch.

Mean values of nutritive value (TDN, SV and DCP) of dried banana wastes through the different experimental treatments are shown in Table (7). Total digestible nutrients (TDN) increased with all biological treatments. The highest increase in TDN was observed with T_2 (29.08%) followed by T_3 (18.92 %) and then T_1 (16.43 %) compared with control. The values of TDN were; 50.89, 60.52, 65.69 and 59.25% for C, T_1, T_2 and T_3, respectively. These increases in TDN value may be due to the increase of CP content of biological treated rations Table (2) and the significant higher apparent nutrient digestibilities coefficients (Table, 7). These results are in good agreement with the findings of El-Ashry *et al.*, (1997) who observed that TDN content increased form 63.93 and 63.35 in control to 72.31 and 72.88 % in fungal treated rice straw and corn stalks, respectively. Also, Khorshed (2000) reported that fungal or yeast treatment increased the nutritive values of corn stalks, wheat straw, rice straw ad cotton stalks form 47.66-54.34 in control to 52.71-56.80 %.

Starch value (SV) content of dried banana wastes increased with all biological treatments (Table, 7). The

Table (7): Effect of different biological treatments of banana waste under solid state fermentation on the nutrient digestibilities coefficient and on the nutritive value of the experimental rations by lactating goats.

Items	Control	T. viride (F-516)	P. funiculosium (629)	S. cerevisiae (AFZ-98)	± SE
DM	53.96^{C}	61.84-^{B}	68.28^{A}	56.55^{BC}	2.11**
OM	56.58^{C}	65.71^{B}	72.08^{A}	60.25^{BC}	1.69**
CP	59.63^{c}	68.49^{ab}	71.45^{a}	64.93^{b}	1.70*
EE	57.32^{b}	64.74^{a}	67.34^{a}	63.31^{a}	1.42*
CF	54.4^{B}	65.45^{A}	68.25^{A}	65.45^{A}	2.05**
NFE	55.79^{C}	66.57^{AB}	71.76^{A}	63.59^{B}	2.23**
NDF	56.62^{b}	62.06^{a}	65.60^{a}	64.13^{a}	1.30*
ADF	55.36^{C}	66.22^{AB}	71.42^{A}	62.40^{B}	1.67**
Hemicellulose	54.34^{B}	65.71^{A}	67.99^{A}	65.98^{A}	2.06**
Cellulose	54.30^{B}	65.70^{A}	67.65^{A}	64.94^{A}	2.00**
TDN	50.89^{Bb}	60.52^{ABa}	65.69^{Aa}	59.25^{ABa}	3.25**
SV	49.12^{Bb}	58.49^{ABa}	63.59^{Aa}	57.24^{Aba}	2.99**
DCP	7.96^{b}	9.36^{a}	9.89^{a}	8.90^{ab}	0.41*

**(P<0.01), [ns]not significant (P>0.05), SE = standard error.

- Significant differences {(P<0.05), small letter} between means, at the same row, are indicated by dissimilar superscripts.
- Each value of means of treatments obtained from 16 values (8 animals).

Table (8): Effect of different biological treatments of banana waste under solid state fermentation on the percent improvements in nutrient digestibilities coefficient by lactating goats.

	Improvements % (calculated)			
Items	Control	T. viride (F-516)	P.funiculosium (629)	S. cerevisiae (AFZ-98)
DM	0.00	14.60	26.50	4.80
OM	0.00	16.14	27.39	6.49
CP	0.00	14.86	19.82	8.89
EE	0.00	12.94	17.48	10.95
CF	0.00	20.31	25.46	20.31
NFE	0.00	19.32	28.63	13.98
NDF	0.00	9.61	15.86	13.26
ADF	0.00	19.62	29.01	13.62
Hemicellulose	0.00	20.92	25.12	19.42
Cellulose	0.00	20.99	24.59	19.59

- All nutrient digestibility coefficient values were improved significantly (P<0.05) by all biological treatments.

highest increase in SV was recorded with T_2 (29.46 %) followed by yeast treatment (T_3) (19.08 %) and then T_1 (16.53 %) compared with control. The respective values of SV were; 49.12, 58.49, 63.59 and 57.24% for C, T_1, T_2 and T_3. These results are will agreed with El-Ashry *et al.*, (1997) (rice straw and corn stalks treated with *P. funiculusms*) and Khorshed (2000) (rice straw and corn stalks treated with *T. viride or S. cerevisiae*). They observed that the biological treatments increased the nutritive value of treated roughages.

Digestible crude protein (DCP) content of dried banana wastes treated with the different biological treatments is shown in Table (7). All the biological treatments improved DCP content of dried banana wastes. The promising results of DCP was observed with T_2 (*P. funiculosiums*) (24.25 %) followed by yeast treatment (T_3) (17.59 %) and then T_1 (*T. viride*)(11.81 %) compared with control. The respective values of DCP were; 7.96, 9.36, 9.89 and 8.90% for C, T_1, T_2 and T_3, respectively. Similar results were obtained by El-Ashry *et al.*, (1997) who observed that DCP content increased form 8.08 and 6.76 in control to 11.74 and 11.58 % in fungal treated rice straw and corn stalks, respectively. These results reveal that biological treatments improved TDN, SV and DCP of dried banana wastes compared with control. These results may be due to using TDN and DCP values to calculated SV value. So, results of DCP and SV followed the same trend as values of TDN values and depending on in vivo digestibility.

The obtained results showed that enzymatic hydrolysis by fungi and the improvement of rumen environment occurred with yeast treatment were as essential of the biological conversion of cellulosic materials and improve the nutritive value of residues especially crude protein and crude fiber.

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تأثير المعاملات البيولوجية على التركيب الكيميائى و معامل هضم المواد الغذائية المقـدر معمليا و داخل الحيوان للمواد الخشنة منخفضة القيمة الغذائية

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تم معاملة أربعة أنواع من المواد الخشنة منخفضة القيمة الغذائية و هى أوراق الموز و حطب الذرة و قش الأرز و تبن القمح بواسطة نوعين من الفطريات هما: *Trichoderma viride* F-516 و *Penicillium funiculosium* (629) و نوع من الخميرة و هو : *Saccharomyces cerevisiae* (AFZ-98) بنظام التخمر فى الحالة الصلبة. و قد أدت هذه المعاملات البيولوجية الى حدوث زيادات معنوية فى محتوى هذه المخلفات من المادة الجافة و البروتين الخـام و كذلك فى معدل اختفاء المادة الجافة و المادة العضوية بمعنوية (على مستوى ١%)، بينما حدث إنخفاضا فى محتوى هـذه المخلفات من الألياف الخام بمعنوية (على مستوى ١%). أدت المعاملات البيولوجية بالفطريات الى إنخفاض معنوى (على مستوى ١%) فى محتوى هذه المخلفات من الهيميسليولوز و السليولوز. أظهرت المعاملات البيولوجية لأوراق الموز أعلـى قيم فى محتواها من المادة العضوية و مستخلص الأثير و المستخلص الخالى من النيتروجين و كذلك أعطت أعلـى معـدل اختفاء للمادة الجافة و المادة العضوية عنها فى المخلفات الأخرى.

لذلك تم تقسيم ثمانية حيوانات من الماعز البلدى الحلابة الى أربعة مجموعات (حيوانين فى كل مجموعة) لدراسـة تأثير أربعة معاملات غذائية، بنظام المربع اللاتينى ٤ x ٤، على النسب الهضمية لأوراق المـوز، و كانـت المعـاملات البيولوجية التالية: (١) مجموعة المقارنة، (٢) المجموعة المعاملة بفطر *Trichoderma viride F-516* ، (٣) المجموعة المعاملة بفطر *Penicillium funiculosium (629)* ، (٤) المجموعة المعاملة بخميرة *Saccharomyces cerevisiae (AFZ-98)* . و قد تم ضبط بيئة تخمر مخلفات أوراق الموز، سواء فى عليقة المقارنة أو المعاملة بالفطريات أو المعاملـة بالخميرة، لتكون رطوبتها حوالة ٦٠%، ثم تم وضعها فى أكياس من البولى إثيلين، و تم إغلاقها ثم حضنت علـى درجـة حرارة الغرفة لمدة ٢١ يوما. ثم تم تغذية الحيوانات على أوراق الموز المعاملة و العلف المركز بنسبة ٣٠ : ٧٠.

و قد أظهرت النتائج أن جميع المعاملات البيولوجية أدت الى زيادات معنوية (على مسـتوى ١%) فـى النسـب الهضمية لكل من المادة العضوية و الألياف الخام و المستخلص الخالى من النيتروجين و الألياف المستخلصة فى المحلـول الحامضى (ADF) و الهيميسليولوز و السليولوز. كما أدت المعاملات البيولوجية لأوراق الموز الى زيادات معنوية (علـى مستوى ٥%) فى النسب الهضمية الظاهرية لكل من البروتين الخام و مستخلص الأثير و الألياف المستخلصة فى المحلـول المتعادل (NDF) . كما أظهرت المعاملة بفطر *Penicillium funiculosium (629)* أعلى تحسن بين المعاملات.

و توصى الدراسة باستخدام المعاملات البيولوجية لتحسين القيمة الغذائية للمواد الخشنة منخفضة القيمة الغذائية ، و خصوصا المعاملة بفطر *Penicillium funiculosium (629)*